THE UNIVERSITY OF ALBERTA

RELEASE FORM

NAME OF AUTHOR Max M. Pinedo

TITLE OF THESIS Policy and Supply Implications on the Availability of Potential Peelable Species for Use in the Peruvian Plywood Industry

DEGREE FOR WHICH THESIS WAS PRESENTED Master of Science

YEAR THIS DEGREE GRANTED Fall, 1984

THE UNIVERSITY OF ALBERTA

Policy and Supply Implications on the Availability of Potential Peelable Species for Use in the Peruvian Plywood Industry

by

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A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES AND RESEARCH

IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE

OF Master of Science

Department of Forest Science

EDMONTON, ALBERTA

Fall, 1984

THE UNIVERSITY OF ALBERTA

FACULTY OF GRADUATE STUDIES AND RESEARCH

The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research, for acceptance, a thesis entitled Policy and Supply Implications on the Availability of Potential Peelable Species for Use in the Peruvian Plywood Industry submitted by Max M. Pinedo in partial fulfilment of the requirements for the degree of Master of Science.

To my parents, and

my wife Helena ...

for her patience

Abstract

Factor and cluster analysis, using specific gravity, modulus of rupture, maximum crushing strength in compression parallel to the grain, and hardness as variables, were applied to aggregate Peruvian species into clusters with proven world-wide veneer species, from North America, Africa and Southeast Asia to assess the potential suitability of Peruvian species for plywood manufacture. Data sets were compiled from world literature.

Six clusters were defined as the optimal number. Four contained a mix of Peruvian and proven veneer species showing that the variables concerned are comparable among the species within each cluster. Two clusters classified only Peruvian species. Thirty Peruvian species aggregated in the first 4 clusters appear to be suitable for plywood manufacture.

To ascertain whether potential peelable Peruvian species found in the cluster analysis can be available to the industry in sufficient quantities, data from several partial inventories and the forest type map were used to calculate growing stock. Due to a lack of growth data, some idea of the relative abundance or scarcity of the resource was measured by determining the number of years of cut that the existing growing stock by species could sustain at particular harvest levels.

It was concluded that although many factors besides specific gravity and some mechanical properties are determinants in defining the suitability of timber species for veneer and plywood manufacture, factor / cluster analysis using the above variables can give useful preliminary groups of potential veneer and plywood species when detailed and more complete data are not available. However, the current inventory data is insufficient and inadequate to estimate growing stock with acceptable accuracy. It is recommended that trials on peeling, drying and gluing be conducted on the species found in the clusters of this study, and that a National Forest Inventory is needed if estimates of the sustainability of the plywood industry are to be made.

Acknowledgements

I am grateful to the Canadian International Development Agency for their financial support enabling me to continue my studies in Canada.

My sincere gratitude is particularly expressed to Dr. Vidar Nordin, Dean of the Faculty of Forestry at the University of Toronto and coordinator of the CIDA Program for the Development of Forestry Education in Peru, whose encouragement of higher education has always been challenging since we met in the Peruvian Amazon in 1974.

I am deeply grateful to my supervisor Dr. James Beck Jr., who suggested the topic of this thesis and for his guidance, patience and positiveness throughout my studies and the preparation of this thesis. His professorship and human values will be forever appreciated.

I want to thank the members of my committee: Professor Barrie Phillips, who provided invaluable assistance to me in using the factor / cluster analysis computer program; and Dr. William Phillips for his suggestions and ideas to improve this project.

I want also to thank the Forest Products Laboratory (Madison) which provided large amounts of data for use in this study and for permitting usage of figures and tables relevant to this project.

My thanks also to Mr. Don Walser, research scientist of Forintek Canada Corp. (Western Laboratory), who let me use the figures relevant to peeling technology.

My thanks are also extended to several individuals who gave valuable suggestions in the early stages of this project. Dr. William Hancock, former research scientist of Forintek Canada Corp. (Western Laboratory); Dr. John Balatinecz, professor of Wood Science and Forest Products at the University of Toronto; research scientists of the veneer and plywood division of the Forest Products Laboratory (Madison); and Dr. Michael Micko, professor of Wood Science at the University of Alberta and former member of my committee.

I would also like to thank the faculty, staff and students of the Department of Forest Science who made my stay in Canada a pleasant and unforgettable experience.

Finally, I want to thank my wife Helena for her constant encouragement throughout the preparation of this thesis and for typing and editing all drafts and the final copy.

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1. Introduction

The plywood industry began in Peru in 1962 when a mill in Iquitos was opened for the production of core stock veneer, mainly for export. Actual plywood production started in 1965 with the establishment of a mill in Pucallpa, Peruvian Amazon. Subsequently, several mills have been set up and there are now 8 in Iquitos and 4 in Pucallpa. The entire industry is located on the Amazon region of Peru.

Lupuna[1] has provided about 95 percent of the raw material for this industry. This tropical species is used for making plywood because of its large diameter, straight and sound stem, and good peeling, drying and gluing characteristics. Its low density and softness have helped peeling without previously steaming the logs. This species grows on alluvial forest types usually on shores of streams as well as small and large rivers. Logging costs have been increasing as the stands closest to the mills and closest to the rivers have been cut first. These increasing costs plus a government change in stumpage price in 1982 have disrupted continuous timber supply to the industry and caused some mills in the Pucallpa area to switch to catahua.

The plywood industry has grown steadily since its establishment. It appears probable that, in light of current shortages of lupuna and considering the interest in capacity expansion, the industry will have to use other species as raw material in the coming years. This study attempts to investigate some aspects of this problem, i.e. what other species should be considered and what volumes are available for use.

1.1 The Forest Resource

The forest resource comprises about 60 percent of Peru's total area of 1,285,215 square kilometers (128.5 million hectares). This area is equivalent to approximately 74 million hectares which is almost entirely tropical rain forest, and lies on the Amazon plain in eastern Peru. It is characterized for its heterogeneity, accounting for

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[1] Due to the large number of species involved in this study, common names will be used throughout and the botanical names of all species are given in Table A.1 (Appendix 1).

about 2500 wood species, of which only 600 have been identified botanically (Lao 1969).

This study will embrace the Departments of Loreto and Ucayali whose capitals are Iquitos and Pucallpa respectively. The area comprises 10 forest districts, where 20 public forests have been established, with a total land area of 27.9 million hectares (ORDELORETO 1980).

According to the forest type map, productive forests are represented by six types, Alluvial classes I, II, and III, and Hill classes I, II, and III (Malleux 1975). Productive forests account for 25.5 million hectares of the total land area of 27.9 million hectares. The balance is covered by mauritia forests (vegetation composed almost entirely of palms of the genus *Mauritia*), swampy areas, forest reserves and agriculture. The current forest land policy adopted by the Forest Service in charge of the Amazon region considers 19.5 million hectares of the productive area accessible.

1.2 Current Harvesting Practices and Problems

From the total forest area, it is estimated that 44 million hectares are harvestable with a present growing stock of over 4 billion m^3 (FAO 1982). The average growing stock is about 100 m^3 to 140 m^3 per hectare in trees over 30 cm dbh[2] (Malleux 1975). At the moment, it is estimated only 0.06 percent of the growing stock is being harvested per year. This is estimated to be about 1 percent of the annual increment. The actual utilized volume accounts for approximately 5 percent of the identified species (Arostegui 1982).

There are a number of constraints which have hindered an efficient and wider utilization of tropical species. On any specific hectare there may be tens of species with widely different properties. Specific gravity may vary from 0.10 or less for balsa to 1.35 for lignum vitae (Collardet 1976). Lack of information of some other characteristics such as durability, sawing and machining, slicing and peeling, drying and gluing among others, has restricted the utilization of a larger number of tropical woods.

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[2] Diameter at breast height measured at 1.3 meters above the ground level (Husch *et al.* 1982 p. 18).

Because of large numbers of species, logging is selective. Light harvest, in conjunction with difficulties and high costs of building roads in the wet and poorly drained soils, has resulted in logging that is confined to those areas near the rivers where logs can be moved easily and cheaply.

1.3 The Problems

A. Can the plywood industry sustain itself or grow on a profitable basis according to the present policies on the utilization of the available forest resource? This question will require careful attention to some factors which the Peruvian plywood industry has faced since its establishment. They are the following:

1. The industry dependance on one forest species, lupuna, which is becoming scarce;
2. Lack of forest inventories in the areas where logging is presently committed; and
3. Little operational knowledge on wood properties of potential peelable species.

B. Can the available data on wood properties be used to suggest potentially useful species to the plywood industry?

C. Can the available inventory data be used to determine the approximate growing stock of potential species for use in the plywood industry?

D. What would be the most applicable policies on timber supply for the future?

1.4 Objectives

The objectives of this study are:

1. To search and analyse data on wood properties of species either presently used or with potential for use in the plywood industry;
2. To relate this available information to the peeling characteristics of wood;
3. To estimate the approximate growing stock for the Iquitos and Pucallpa regions;
4. To estimate the number of years of cut that could be sustained at different utilization levels; and

5. To make relative policy statements about how the government might influence harvest and utilization of the forest resource supporting the plywood industry.

2. Background Information

2.1 Introduction

The first part of this review describes general information known about veneer and plywood manufacture. Three broad aspects are outlined under different subheadings; the wood properties, log characteristics, and the conditions necessary for veneer cutting.

The second part reviews the concepts of growing stock and allowable cut.

2.2 Veneer and Plywood Production

2.2.1 Physical Properties of Wood

Generally, the first available information of wood species are their physical and mechanical properties. Some physical properties of particular interest for veneer are described in the following subheadings.

2.2.1.1 Specific Gravity

Specific gravity[3] is an important factor in determining the physical and mechanical properties which characterize different kinds of wood. The amount of wood substance in a piece of wood is a reliable indicator of its strength properties and, to some extent, of its working and finishing characteristics as well (Brown *et al.* 1952).

Lutz (1978) reports the importance of specific gravity as a general guide in screening woods for use as veneer. He mentions that the knowledge of specific gravity for some pines proved important in establishing the southern pine plywood industry in the

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[3] Density and Specific gravity are interchangeably used concepts. While both terms bear the same numerical values, they are expressed in different units.
"Density is defined as the mass or the weight of any substance per unit of volume." (Brown *et al.* 1952 p.1).
"Specific gravity is usually expressed as a ratio of weight of the substance to the weight of an equal volume of water." (Panshin and De Zeeuw 1980 p.212). Since the numerator and denominator are expressed in the same measurements, these cancel, and the resultant is a pure number. The term specific gravity will be used throughout this study.

United States. Because the strength of wood is related to specific gravity; and based on strength values and specific gravity records, the major southern pines, loblolly, longleaf, shortleaf and slash, were marketed in the same category as West Coast Douglas-fir.

Specific gravity also has influence in the cutting of wood into veneer. Lutz (1978) states that in spite of the appropriate manipulation of the cutting conditions, it is more difficult to cut wood at the two extremes of the range of specific gravity. Very lightweight timbers tend to cut with a fuzzy surface. On the other hand, dense woods tend to develop deep cracks in the veneer as they pass over the knife. Generally, species with medium specific gravity between 0.40 to 0.60 cut better into veneer (IUFRO 1976).

Specific gravity also has importance in veneer gluing. Lutz (1978) reports that the denser the wood, the more difficult it generally is to glue.

Typical specific gravities of woods used for construction plywood are 0.41 to 0.55; for hardwood face veneer 0.43 to 0.65; for core and crossband veneer of decorative panels 0.32 to 0.45; and for container veneer 0.36 to 0.65 (Lutz 1978).

2.2.1.2 Green Moisture Content

Lutz (1978) states that although moisture content in the wood is generally not a decisive factor in ascertaining whether that wood is suitable for use as a veneer, it has a distinct effect on cutting, and in general wood with a moisture content above the fiber saturation point[4] but not excessively high is best suited for cutting into veneer. Adequate moisture content in wood gives mechanical support to the cell walls during cutting. He also mentions that in a number of studies carried out at the Forest Products Laboratory (Madison), it was found that species with a natural uniform moisture content of about 50 to 60 percent cut well.

Feihl *et al.* (1977) also indicates that a veneer log must be green for good peeling performance. Logs allowed to dry develop heart shakes and produce rough (and often

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[4] "The fiber saturation point represents the moisture content (approximately 30 percent) at which the cell wall is completely saturated with water, but no moisture is present in the cell lumen." (Panshin and De Zeeuw 1980 p.203).

splintery) veneer.

Moisture content is also important in drying veneer. Because of different moisture contents in sapwood and heartwood, it generally pays to separate sapwood and heartwood veneer for drying. Species with very high moisture content, such as 200 percent, may not dry successfully into veneer (IUFRO 1976).

2.2.1.3 Permeability

Permeability[5] has an important effect on veneer cutting, drying, and gluing characteristics (Lutz 1978). Permeable woods are easier to cut because water is readily forced from the wood. Thus, plywood made from veneer that is naturally permeable is less subject to blister during hot pressing than plywood made from less permeable veneers.

Conversely, extremely permeable veneers may require more glue spread or changes in gluing techniques to obtain satisfactory bonding results.

2.2.1.4 Shrinkage

Lutz (1978) reports that a small degree of shrinkage[6] is desirable for woods that are to be cut into veneer. High shrinkage is undesirable because of its detrimental effects on plywood manufacture. High shrinkage places more stress on plywood gluelines with changes in moisture content; it also may cause cracks in face veneer of crossbanded panels during service; and it causes warping unless the crossbanded panels are perfectly balanced. Shrinkage is a factor in all veneer uses but perhaps is most important for crossbanded veneer.

Among tangential, radial and volumetric shrinkage, tangential shrinkage of wood is an excellent indicator of drying performance. Tangential shrinkage indicates the widthwise shrinkage of rotary-cut and flat-sliced veneer (Lutz 1972).

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[5] "Permeability in wood is related to the sizes of the passages that are available for flow of liquids or gases." (Panshin and De Zeeuw 1980 p.207).

[6] "Shrinkage of wood refers to changes in its dimensions and in its volume resulting from changes in moisture content below the fiber saturation point." (Brown *et al.* 1952 p.36).

2.2.1.5 Texture and Grain

Texture is relatively unimportant in veneer cutting and drying but may be important in finishing (Lutz 1978). However, species with a homogeneous texture peel smoother than the others and this is particularly true for logs whose pith is not at the center (Feihl *et al.* 1977).

Straight grain is desirable for ease of veneer processing and for most end uses (Lutz 1978). Straight grained veneer logs are also easier to cut than irregularly grained woods and the veneer is more likely to remain flat.

2.2.1.6 Extraneous Materials in Wood

Wood is chiefly composed of the following substances: cellulose, lignin, hemicellulose, extractives and ash-forming minerals (USDA 1974). The last two constituents are not part of the wood but contribute to properties such as color, odor and resistance to decay. They include resins, waxes, hard deposits and the like.

Lutz (1978) mentions the significance of those elements in the cutting and gluing of veneer. He reports that gluing and finishing problems are associated with the presence of resinous and waxy deposits in wood.

Resin is a disadvantage in veneer cutting, whereas waxy extractives seem to be an advantage. Hard deposits containing calcium, magnesium or silica have a clear blunting effect on sharp tools. If the silica content in wood exceeds 0.5 percent, it causes rapid dulling of cutting tools.

FAO (1966) reports also that silicate inclusions can cause considerable trouble in the sawing and machining of the dry plywood.

2.2.2 Mechanical Properties of Wood

Lutz (1978) points out that mechanical propeties of specific interest for veneer are:

1. Strength in tension perpendicular to the grain.

2. Hardness

3. Modulus of elasticity

4. Modulus of rupture

5. Shear

6. Compression parallel and perpendicular to the grain.

Tension perpendicular to the grain is important in woods for veneer manufacture because it is less probable to split while in log form when cutting into veneer or in the subsequent handling of the veneer.

Hardness is important in veneer used for furniture and flooring, and also in places where veneer will be impacted and receive abrasion during service.

Modulus of elasticity, or stiffness, is an important and critical factor in plywood for structural uses such as subflooring and roofing.

The ultimate bending strength of the wood is measured by the modulus of rupture, and it is of interest for construction plywood and containers.

When plywood is used in structural applications such as the web in a box beam, shear is an important characteristic.

Compression parallel to the grain is important when plywood is used as a stressed skin.

When a bearing load is involved, such as a refrigerator on a plywood subfloor, compression perpendicular to the grain is an important property.

2.2.3 Log Characteristics

In addition to the physical and mechanical properties of wood species, their tree and log characteristics must also be considered. Lutz (1978) outlines characteristics of interest for veneer logs, some of which are described below.

2.2.3.1 Diameter and Log Form

Large diameter logs are preferred for all veneer cutting, other factors being equal (Lutz 1978). Nowadays, however, with the achievement of new and improved peeling technologies, logs with as small a diameter as 15 cm (6 in.) can be peeled down to a core diameter of only 6-6.5 cm (2.4 to 2.6 in.) (King 1977).

It is important that veneer logs have a cylindrical form with the pith in the geometrical center of the log ends if they are to be used in rotary cutting (Lutz 1978). Results from industrial and laboratory tests show that 5 to 6 percent of a typical veneer bolt is lost in rounding it before obtaining usable veneer.

2.2.3.2 Taper, Eccentricity and Sweep

Lutz (1978) describes the importance of these log characteristics in veneer peeling. Taper causes short grain in rotary cut veneer, and such short grain is weak in bending and shrinks excessively in length. Taper is also a problem in peeling because short length veneer or fishtails generally are not usable.

Logs having pronounced eccentricity result in narrow pieces of rotary cut veneer. This veneer tends to be rougher than veneer cut from cylindrical logs because a part of each revolution of veneer is cut against the grain of the annual rings. Eccentric logs frequently also have abnormal wood which is called tension wood in hardwoods, and compression wood in softwoods.

Sweep or lengthwise curvature in logs is a problem for both rotary and sliced veneer because these logs often present abnormal wood, and sweep limits the number of full length sheets that can be produced from the log.

2.2.3.3 Abnormal Wood

Tension wood or compression wood are often found in logs with the pith off center, and both of these forms of abnormal wood shrink more in length than normal wood resulting in buckling of the veneer drying (Lutz 1978).

2.2.3.4 Log End Splits due to Growth Stresses

Log end splits are a serious handicap in logs used in rotary cut because either the bolt is lost from splitting during cutting, or from similar splits in the veneer (Lutz 1978).

A summary showing the importance of all of the wood properties and log characteristics, and their relative importance according to the end use is given in Table 1.

2.2.4 Important Factors to Consider before Veneer Cutting

Two important and critical factors in an efficient veneer and plywood operation are reviewed; they are: protection of veneer logs in storage and the conditioning of wood prior to cutting veneer.

2.2.4.1 Protection of Veneer Logs in Storage

Lutz (1978) reports that suitable storage conditions are necessary to avoid deterioration of veneer logs by drying and cracking of the log ends and other exposed wood; development of decay; blue stain and oxidation stain; attack by insects; development of undesirable odor; and increased porosity due to attack by bacteria.

Many tropical hardwoods are susceptible to blue stain and treatment is required immediately after felling; tests in Cameroon have indicated that fungicide treatment of timber 24 hours after felling was too late to stop staining fungi (FAO 1966).

Lutz (1978) mentions that some tropical hardwoods like muritinga, ceiba, and cativo are subject to attack by anaerobic bacteria even though the wood is kept wet; this causes displeasing odor in those woods.

Feihl (1978) points out that most protective measures in log storage are based on the following observations:

1. Stain and decay are caused by fungi and it cannot develop if the wood is fully saturated with water, or if the moisture content in wood is below 20 percent.
2. Insects have certain requirements for oxygen and humidity. If there is a lack of oxygen, or if the wood is too humid, insects cannot survive.

Table 1 Importance of Physical and Mechanical Wood Properties and Log Characteristics as Related to Manufacture and Use of the Veneer. *

Property	Construction and industrial plywood	Decorative face veneer	Core and crossband veneer for decorative panels	Container veneer and plywood	Comments
Physical property					
Specific gravity	A	B	A	B	
Green moisture content	B	B	B	B-C	
Permeability	B	C	B	B-C	
Shrinkage	B	B	A	B	
Close grain	B	A-B	A	B-C	
Fine texture	C	B	B	C	
Straight grain	A	A-B	A	B	
Parenchyma	B	B	B	B-C	
Wax	B	B	B	B	
Polyphenols	B	B	B	B	
Color of heartwood	C	A	C	A-B	
Dimensional stability	B	B	A	B	
Resin	B	A	A	B	
Gum	B	A	A	B	
Hard deposits	B	A-B	B	B	
Figure	C	A	C	C	Figure is desirable for face veneer and undesirable for other uses
Odor	C	A	A	A	Odor is important for containers used with food.
Mechanical property					
Strength in tension perpendicular to grain	B	B	B	B	
Hardness	B	B	C	B	
Modulus of elasticity	A	C	C	B	
Modulus of rupture	A	C	C	A	
Shear	A	C	C	C	
Compression perpendicular to grain	A	B	C	B	
Compression parallel to grain	A	C	C	B	
Log characteristic					
Cylindrical form	A	B	A	B	
Taper	A	B	A	B	
Eccentricity	B	B	B	B	
Tension wood	B	A	A	B	
Compression wood	A	B	A	B	

Table 1 Importance of Physical and Mechanical Wood Properties and Log Characteristics as Related to Manufacture and Use of the Veneer. -- continued

Property	Construction and industrial plywood	Decorative face veneer	Core and crossband veneer for decorative panels	Container veneer and plywood	Comments
Sweep	A	B	A	B	
Growth stress	B	B	B	B	
Log end splits	A	B	B	B	
Ring shake	A	A	A	A	
Knots	B	A	A	B	
Epicormic branches and adventitious buds	C	B	B	C	
Burls	B	B	B	B	
Color	C	A	C	B	
Pitch pockets	B	A	A	B	Pitch in crossbands may bleed through face veneer
Bark pockets	B	A	A	B	
Grub holes	B	A	A	B	
Pinworm holes	B	B	C	B	Heavy pinhole damage will degrade all veneer
Decay	A	A	A	A	Some types of decay are permitted in Construction grade plywood
Fire scars	B	A	A	B	
Frost cracks	B	A	A	B	Veneer from other parts of the log may be top grade
Mineral streak	C	A	C	C	
Other stains	C	A	C	B	
Bird peck	C	A	B	B	
Stump pull	A	A	A	A	
Felling splits	A	A	A	A	
Handling damage	A	A	A	A	
Embedded metal	A	A	A	A	
Growth rate	B	A	B	B	

A - Of major importance
B - Of moderate importance
C - Of little importance
- The above ratings are not hard and fast but are indicative of relative importance of various characteristics.

* Reproduced from Wood veneer: log selection, cutting, and drying (Lutz 1978) with the permission of Forest Products Laboratory, Forest Service, U.S. Department of Agriculture, Madison, WI 53705.

3. Oxidation stain cannot occur without oxygen.

Feihl (1978) outlines five different protective measures for logs in storage:

1. Ponding (log storage in a pond, river or lake)
2. Sprinkling with water
3. End coating
4. Chemical spraying
5. Cold storage

2.2.4.2 Conditioning of Wood Prior to Cutting Veneer

Some benefits and disadvantages resulting from heating peeler logs in steam or water prior to veneer cutting have been reported. The most outstanding advantages according to Lickess (1957) are: increased recovery of veneer, longer life for lathe knives, easier peeling from a mechanical standpoint, faster veneer drying because some heat is stored in wood and steam wood is more permeable, improved gluing characteristics, smoother unsanded panels, and more easily sanded faces for finished plywood panels.

Lutz (1978) and Bauer (1980) cite that the obvious effect of heating logs is tighter veneer cutting than cutting from unheated wood. Tighter cutting signifies greater strength in tension perpendicular to the grain of the veneer, and thus less splitting of the veneer in handling and less checking of face veneer in service. Heating is also important if tight veneer is to be produced in thicknesses of 1/8 in. or greater, because wood becomes more plastic and less resistant to fine checking, thus reducing deep splits.

A general consensus, as reported by Bauer (1980), is that hot water soak vats are generally more efficient for conditioning blocks than steam vats, provided that the water heat exchanger design is adequately engineered. Resi-Vat [7] is used in conjunction with the hot water heating medium in the log soak vats. The heating plasticizes the wood resulting

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[7] Resi-Vat is a product developed by Georgia Pacific Corp. for accelerating the block conditioning process and it is a combination of alkaline chemicals.

in smoother and tighter veneer peeling. The wood is further plasticized by the hot alkaline treatment yielding better quality veneer and improved grade recovery. Veneer peeled from blocks treated by this method can also be dried at a faster drying schedule.

Most disadvantages of heating (Lutz 1978) can be credited to using too high a heating temperature or too long a heating time. Some problems may arise by overheating, such as excessive end splits in bolts on certain species, darkening of the veneer, increased spinout of bolts by softening the end grain, or enhanced shrinkage. The heating temperature, however, must be exceedingly high and the heating time exceedingly long to affect the durability and strength of the wood.

Consequently, the heating of logs (Fleischer 1959) to be cut into high quality veneer needs a knowledge of the proper temperature for various species and conditions, and also of the factors that determine the achievement of these temperatures during the heating process.

2.3 Growing Stock and Allowable Cut

A cornerstone of forest management for timber production is the provision of a sustained flow of harvested products. The desirability of obtaining a regular harvest is stated in the following:

> "A yearly cut of an approximately equal volume, size, quality, and value of timber provides a stable business planning base. It also defines the need for additional timber if needed to supply dependent processing plants which must operate on a regular basis, often with rather narrow limits." (Davis 1966 p. 99)

To obtain equal annual or periodic yield of timber products, a regulated forest is the usual goal. Two kinds of forests, those composed of even-aged and uneven-aged stands, are viewed from a regulatory standpoint (Davis 1966).

Davis (1966) and Schmithusen (1977) report the importance of the allowable cut as an instrument of any wood utilization policy intended to stabilize the forest industry of a country or a particular region.

The allowable cut policy is an efficient means of limiting the annual logging volume if overcutting and excessively rapid depletion of the forests are to be avoided. However, its determination requires fundamental parameters such as: reliable inventory data providing basic information on the quantity of timber by species and size-class distribution available in each unit, and accurate information on the annual increment of the different species.

Unfortunately, as Schmithusen (1977) notes, there is very little information available on increment in many countries, and particularly in those with tropical hardwood forests. In those areas the annual increment is hard to ascertain without a series of growth records. Tropical forests, in contrast to management of temperate forests, still lack a proper tool for ascertaining age and growth (Ewel 1982).

Because this study deals with mixed unmanaged tropical forests, the focus of this review is oriented toward uneven-aged management. The distinctive feature of an uneven-aged stand (Davis 1966) is that it has neither a beginning nor has it an end; after harvest it has a certain volume of growing stock, it grows for a period of time (cutting cycle[8]), a cut is taken, and the sequence is repeated.

The fundamental distinction between even-aged and uneven-aged stands with respect to management is that in even-aged management, the cut is determined in relation to the rotation and that the rotation also substantially controls the management framework. In uneven-aged management, the cut is determined in relation to the cutting cycle, growing stock level, and the rate of volume growth.

In determining the allowable cut,[9] there are two general approaches (Davis 1966). They are: area control and volume control. In determining the sustainable cut by area control, a certain area of timber is available for harvest each year. The amount of cut per

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[8] Cutting cycle is defined "as the planned interval between major felling operations in the same compartment or other permanent subdivisions of a forest." (Meyer *et al*. 1952 p.166).

[9] "Allowable cut is the amount of timber considered available for cutting during a specified planned period of operation." (Davis 1966 p. 122).

unit area as applied to an uneven-aged forest is ascertained by growth calculation over the cutting cycle. It is simple and direct, but growth information on the forest in which it has to be applied needs to be known.

Volume control methods are based on either growing stock or increment, or a combination of both. A method based entirely on growing stock is von Mantel's formula, but it requires the knowledge of rotation for its application. Taylor (1962) reports that von Mantel's formula is a method of yield calculation which has been applied in tropical and subtropical forests. However, because von Mantel's formula was developed to determine the cut in even-aged forests, past use or any future use of this method in determining the cut of uneven-aged forests is incorrect.

3. General Methodology

3.1 Available Data

3.1.1 Physical and Mechanical Properties of Wood Species

In this study, data on physical and mechanical properties for Peruvian species and proven foreign veneer species, including tropical hardwoods from Africa and Southeast Asia, and hardwoods and conifers from North America, were examined and compiled from world literature. These data were used for comparison between Peruvian and foreign species to assess the potential suitability of Peruvian species for plywood manufacture.

3.1.2 Resource Inventories

Data from several partial forest inventories carried out in different zones of the Peruvian Amazon and the forest type map for the region were reviewed and used in this study.

3.2 Selection of Species for Use in the Plywood Industry

Several wood and log characteristics affect veneer and plywood production, but in general certain parameters such as volume, size and form of the trees are important to know, as well as the physical and mechanical properties of the wood (Lutz 1971). However, a final judgement of the veneer potential of a species can only be made on the basis of veneer cutting and drying evaluations either at a research or industrial level.

It is not always possible to acquire all the relevant information on the tropical woods to be used in plywood manufacture. Nevertheless, the first data on hand are physical and mechanical properties of the wood. Specific gravity is the parameter to be used when quickly screening new species for tentative classification (Lutz 1971). It also

has an important influence on the strength of wood, with some strength properties more closely related to it than others. Hardness is probably the quality most closely associated with specific gravity (Findlay 1975; Core 1969). Specific gravity values,[10] when used in conjunction with other knowledge and characteristics, are useful in predicting performance. There is an almost linear relationship between maximum bending strength (modulus of rupture), maximum compression strength (maximum crushing strength) and hardness, and specific gravity (Findlay 1975). By comparing certain characteristics such as specific gravity, modulus of rupture, maximum crushing strength and hardness to the same characteristics of well known veneer species, it is possible to ascertain at a glance, the potential peelability of a species. This type of comparison provides a convenient reference basis if a substitute species of similar strength is sought (Bendtsen and Chudnoff 1981). However, similarities in some properties do not imply similarities in all properties. In order to group Peruvian species and foreign species for comparison, factor analysis and cluster analysis were used.

3.2.1 Cluster Analysis

Cluster analysis was used to aggregate Peruvian and known foreign plywood species into similar groups in relation to their potential for plywood production. Because of the linear correlation indicated above by Findlay (1975), factor analysis [11] was used to account for as much variation as possible while removing the undesirable effects of correlated variables (Beck and Phillips 1980). The factors which were produced are

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[10] Specific gravity records for all species in this study are based on green volume and ovendry weight. Specific gravity on a volumetric basis other than green may be approximated by using the chart in Figure 1 (USDA 1974). The use of the chart is illustrated as follows: assume the specific gravity based on green volume and ovendry weight is 0.55 and it is desired to find the specific gravity for a 12 percent moisture content condition. Enter the chart at the 12 percent moisture content and move vertically to the point where this line intersects the 0.55 specific gravity value (between diagonal 0.54 and 0.56) and move horizontally to the left-hand scale to read the 0.60 specific gravity value (IUFRO 1976).

[11] Factor analysis was performed using the principal-components and varimax rotation option available in the Statistical Package for the Social Sciences (SPSS) (Nie *et al*. 1975).

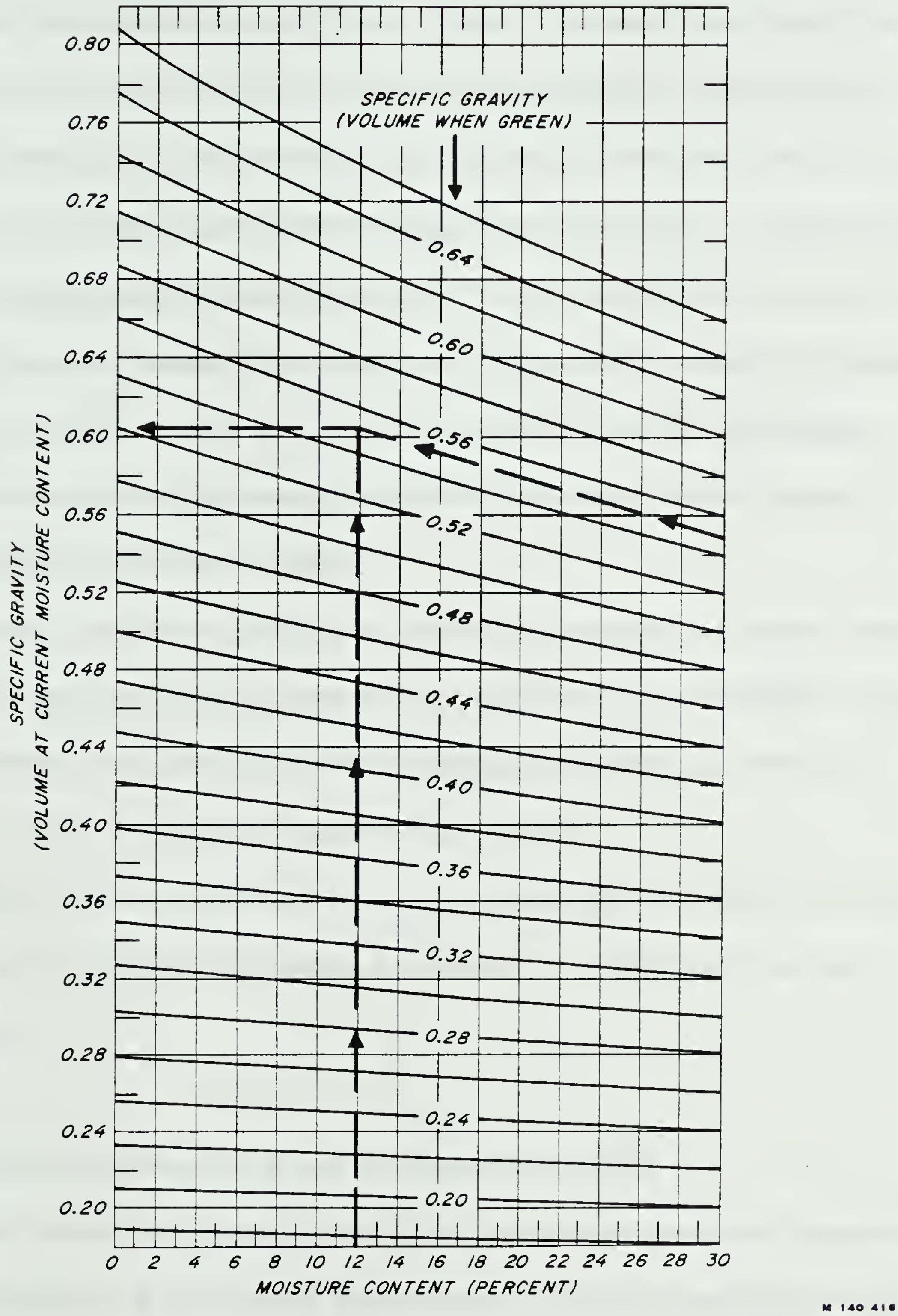

Figure 1. Relation of specific gravity and moisture content.

Reproduced from Wood handbook (USDA 1974) with the permission of Forest Products Laboratory, Forest Service, U.S. Department of Agriculture, Madison, WI 53705.

statistically independent, normalized linear combinations of the original variables. The resulting factor scores were then used as input to cluster analysis.

Cluster analysis is a family of techniques for grouping subjects that are similar with respect to a set of descriptive variables (Turner 1974). This means that there should be small variances within groups and large variances between groups. Cluster analysis techniques have been amply used in ecological, taxonomic and marketing research, and the techniques (Turner 1974) have given useful results in many other areas. Cluster analysis was also used to aggregate land units into data sets for land management models, mainly Timber RAM (Williams and Yamada 1976; Beck and Phillips 1980). A study of the end-use determination of wood species for sawn timber and roundwood also used cluster techniques in developing a model named Specific End-Use Determination System (S.E.U.D.-System) (Dielen and Raven 1982).

In this project, subjective grouping of species was rejected and factor / cluster analysis applied to aggregate Peruvian species into groups with known peelable foreign species to see whether they are likely candidate species for peeling. A computer program based on Ward's technique was used in the study.[12]

The choice of which variables and factors to include and the number of clusters desired is difficult. Professional judgement is necessary to decide upon the most adequate alternative.

3.3 Determination of Growing Stock and Allowable Annual Cut

Because of insufficient inventory data, three approaches were tried to determine if reasonable estimates of growing stock can be made for potential peelable Peruvian species found in the cluster analysis.

The first method intended to estimate by species, average volume per unit area for each forest type (Alluvial I, II, and III, and Hill I, II, and III) in all available forest inventories.

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[12] Ward's technique is described in Williams and Yamada (1976). It is a hierarchical method that uses distance as a measure of dissimilarity.

Growing stock by species would be estimated using these figures multiplied times the area of the respective forest type in the entire subregions of concern in Peru.

A second approach attempted to use average volume per species per unit area by public forest without considering forest types which would have been multiplied times the area of the respective public forest. Then growing stock by public forest would have been summed for each subregion of concern in Peru.

The third used average volume per unit area per species applied to the area of the subregion of concern in Peru.

Because of lack of growth data, allowable cuts could not be calculated. To get some idea of resource availability or scarcity, the number of years of cut at different utilization levels was determined for each species for each subregion of concern.

4. Determination of Potential Peruvian Plywood Species

4.1 Analysis of Wood Properties

Lack of utilization of lesser known tropical woods has been one of the main constraints in the further development of tropical forest industries. In the Peruvian Amazon, selective cutting has been practiced for decades to supply an incipient lumber industry, and utilization was centered on two valuable species, caoba and cedro.

As indicated previously, the Peruvian Amazon forests are highly heterogeneous and the scientific knowledge of hundreds of species growing in that area is very limited. Arostegui (1982) reports that only about 150 species have been studied to determine their anatomical, physical and mechanical characteristics, as well as their response to other aspects such as drying, preservation and workability for uses other than in veneer manufacture. No research has been conducted to define the use of such species in wood-based panels.

It is assumed limited knowledge on this matter that has resulted in the plywood industry's concentration primarily upon only one species since its establishment. Now that this species is becoming scarce in accessible areas, others must be found to supply the mills.

Lack of research on peeling, drying and gluing of veneer has limited the usage of lesser known species in plywood production. Moreover, the industry has been reluctant to test new species at the industrial level. Nevertheless, it appears that in the absence of research, industry will have to begin to test new species.

Based on these considerations, this project attempts to ascertain if lesser known species and others currently used as sawn timbers, based solely on their wood properties, can be suggested for further testing for possible use in veneer and plywood manufacture.

Available data on physical and mechanical properties of Peruvian timbers were recorded from several studies on wood properties (Arostegui y Acevedo 1971/1974; TRADA 1979; Arostegui *et al.* 1980/1981; JUNAC 1981a, 1981c; Arostegui 1982). Data was analysed and 59 species were selected (Table A.2, Appendix 1). This selection was based on the reliability of results from tests carried out to determine physical and mechanical properties of the wood. Among important considerations reviewed were the moisture condition of wood at which the tests were carried out and the test methods used to establish mechanical values.

These were determinant factors to verify if the available data could be used as means of comparison with foreign species. It is reported in the literature that values of mechanical properties for selected species were acquired from tests of wood specimens performed in the green condition. Data adjusted to a common moisture content base of 12 percent was only available for 19 species. Because of unavailable data for seasoned wood and to unify criteria for comparison, only values of mechanical properties in the green condition were used in this study.

All tests were conducted following the specifications of the American Society for Testing and Materials (ASTM 1952, 1973), and adaptations of these standards for use in the Peruvian conditions (Arostegui 1975). The values are presented in metric units.

Apart from mechanical properties, certain physical characteristics, where available, such as type of grain, texture, color, figure and the presence of extraneous materials in the wood were also studied. It is important to emphasize that these features were obtained from wood samples used in the determination of basic wood properties and some characteristics may not have the same appearance in veneer. Possible physical and mechanical properties for use in this study are: specific gravity (green volume and ovendry weight), green moisture content, tangential, radial and volumetric shrinkage (green to ovendry), texture, grain, color, and figure; modulus of elasticity, modulus of rupture, compression parallel to the grain - maximum crushing strength, hardness (side), shear

parallel to grain - maximum shearing strength.

Details and values of physical and mechanical properties by species are found in Tables A.3 and A.4 in Appendix 1.

4.2 Foreign Species Used in Plywood Manufacture

4.2.1 Species Selection

Hundreds of species, presently used or with potential for use in veneer, grow in the temperate and tropical forests around the world (Lutz 1972; IUFRO 1976). Perhaps the bulk of data on cutting and drying of veneer as well as quality and uses of dry veneer are from conifers and hardwoods that grow in temperate regions. These areas still remain the main suppliers of wood for veneer and plywood production on a world wide basis.

Veneer species from three major regions including North America, Southeast Asia and tropical Africa were examined in this project.

In order to choose species for comparison from the hundreds reported in the literature, three important factors were considered: available data on physical and mechanical properties, suitability of species for peeling based on research and/or industrial experience and commonly used plywood species in each region.

Species composition of United States plywood production is almost all coniferous, mainly Douglas-fir and southern pines, loblolly, longleaf, shortleaf and slash, with minor contributions from other species such as western hemlock and ponderosa pine. In Canada, 80 percent of plywood is coniferous and 20 percent non-coniferous. The coniferous plywood is mainly made from Douglas-fir, and minor production from spruce and pine. Non-coniferous plywood is produced from poplar, birch and other decorative hardwoods.

In Southeast Asia, the bulk of plywood production comes from several species grouped under the genera *Shorea* and *Dipterocarpus*. In tropical Africa, plywood is produced from many species, but mainly from species such as obeche, okoume or gaboon, sipo, African mahogany and sapele.

Species suitable for veneer and plywood production were determined from a study of the International Union of Forestry Research Organizations - Working Party on Slicing and Veneer Cutting (IUFRO 1976). Forty five species were selected to be compared with Peruvian species (Table A.5, Appendix 1). Physical and mechanical properties for these woods were obtained from world literature (Kukachka 1970; Lutz 1972; USDA 1974; IUFRO 1976; Okoh 1977; Chudnoff 1980; Panshin and De Zeeuw 1980; Mullins and McKnight 1981; JUNAC 1981a, 1981b) (Tables A.6 and A.7, Appendix 1). To have fairly uniform, reliable data, it was necessary to examine certain parameters previously described in the analysis of Peruvian species. They included wood moisture condition at which tests were carried out in the determination of mechanical properties, test methods, and the units system in which values were presented.

Hardwoods and conifers from North America have been amply investigated and knowledge on their wood characteristics is quite complete and accurate. The strength values are averages for the species and were determined following ASTM procedures. In contrast, most tropical hardwoods have not been studied as accurately. As a result, a diverse range of values can be found in the literature.

In the case of species from Asia and Africa, detailed analysis of the literature on wood properties was necessary. The values obtained from sources compiled at the U.S. Forest Products Laboratory presented the most consistent results. These values were converted into ASTM standards from the British Laboratory standards using the conversion factors recommended in their Research Bulletin No. 50 (Kukachka 1970).

Mechanical properties for all selected species were available from wood tests in green condition and adjusted values for seasoned wood (generally 12 percent). For the

purpose of this project, only values obtained in the green condition were used.

Data on North American, Asian and African woods were presented in imperial units. It was necessary to convert all values into metric units to make them comparable to values obtained for Peruvian woods.

4.2.2 Raw Material for Veneer and Peelable Characteristics of Wood

Basically, two criteria are used in assessing the suitability of a timber for veneer and plywood (FAO 1966). The first pertains to the timber in log form. This aspect involves log size, volume and quality and grades. The second criteria concerns the physical attributes of wood which determine the technical considerations of a species for veneer and plywood manufacture. They include peeling or slicing characteristics, appearance, gluing and finishing characteristics, and structural characteristics.

Selection of foreign species in this project was based not only on the knowledge of their physical and mechanical properties but also on their good performance in cutting and drying evaluations either at a research or industrial level.

Certain parameters such as specific gravity, green moisture content, widthwise shrinkage and bolt conditioning are fundamental parameters for performing satisfactory peeling operations. The ease of veneer cutting as well as successful veneer drying are influenced by these factors.

Some of these factors, together with color and figure of veneer obtained in rotary and sliced methods are presented in Table A.8 (Appendix 1) for all selected foreign species.

4.3 Results and Discussion

Five strength values (modulus of elasticity, modulus of rupture, maximum crushing strength, hardness, and maximum shearing strength) and specific gravity were initially chosen for each of the 104 selected species for comparison in this study. These six variables were used in the factor / cluster analysis. Strength in tension perpendicular to grain, compression perpendicular to grain, moisture content and shrinkage were not used because data was unavailable for most non-North American species. Other physical characteristics such as texture, grain and color were rejected from use in the analysis due to the subjectiveness involved when defining these parameters for any particular species. Moreover, because these variables are not numerical, it is again a subjective exercise assigning them specific values to enable their usage as data.

From the mathematical standpoint, the five strength properties and specific gravity were strongly correlated with each other. However, the approach including these six variables led to clusters with the species having a wide range of values for hardness, i.e. soft species were aggregated with hard species. This characteristic was undesirable from a technical viewpoint. A second series of factor and cluster analyses was made including those variables suggested by Findlay (1975): specific gravity, modulus of rupture, maximum crushing strength and hardness. These four variables led to clusters with species clearly comparable from a technical standpoint.

In both the six variable and four variable analyses, only one factor was used in clustering because it accounted for 92.5 % and 95.4 % of the variation respectively.

The optimal number of clusters for the purpose of this project was found to be 6. Four groups contained a mix of Peruvian and foreign species while two groups contained only Peruvian species.

To define the optimal number of clusters, it was necessary to closely analyse the species aggregated in each cluster. There are no definite ranges of strength values for grouping species (Bolza and Keating 1972; Berni *et al*. 1979; Arostegui 1982), but

because specific gravity is related to the strength of wood, it was used as an important criterion to determine the most suitable number of clusters.

The specific gravity value ranges for grouping of species reported in FAO (1980) were used as an indicator. It defined values for low, moderately low, medium, moderately high and high specific gravity with ranges .40 and below, .41 to .50, .51 to .60, .61 to .70 and .71 and above respectively. Most Peruvian and foreign species aggregated in clusters 1 and 2, 3, 4, 5, and 6 are within the ranges of low, moderately low, medium, moderately high and high specific gravity values respectively.

In addition, professional judgement was used to stop further aggregation of species to less than 6 clusters. Clusters 1 and 2 grouped together if 5 clusters were used. Aggregation of both clusters would have placed lupuna and its comparable foreign species with others having much higher strength values especially for hardness and would not have given a reliable comparison. The species aggregated in group 3 were also a good indicator of the optimality of the number of clusters selected. The major southern United States pines, loblolly, longleaf and shortleaf, were placed together with Douglas-fir. In the world market, these are competitive substitutes for each other.

Subsequently, each cluster containing Peruvian and foreign species was analysed separately. Fourteen Peruvian species were rejected from clusters 1 to 4 based on literature and analysis of certain technical considerations which were not considered by the cluster analysis. They dealt mainly with workability, color of wood related to hardness and the presence of hard deposits in wood which make it difficult to process efficiently.

The Peruvian and foreign species in each cluster are found in Tables A.9, A.10, A.11, A.12, A.13 and A.14 (Appendix 1). The tables show Peruvian species compared with foreign species of approximately equivalent properties. Shown also are some other characteristics not used in the final cluster test, as well as the relative suitability for use for all foreign species.

For convenience, the species are arranged in ascending order of specific gravity in all tables. Thirty Peruvian species distributed in the first four groups appear to be suitable for veneer and plywood manufacture.

The single species lupuna in Table A.9 compares favcurably with all four foreign species and its strength values rank between those of bonga and black cottonwood. Lupuna makes an excellent inner ply and face veneer for utility plywood.

Most species with specific gravities between .35 and .42 were grouped in Table A.10. Peruvian species are equivalent in their strength values to foreign species. Most foreign species in this group are best suited for use as inner plies and container plywood, and so the main potential of Peruvian species in this group would be in those categories. Cedro, placed in this group, is one of the most valuable sawn timbers in Peru.

Table A.11 shows most species with specific gravities between .40 and .50. In this group Peruvian species are more uneven in certain physical characteristics such as texture, grain and color, but quite similar in their strength values. In this group, most foreign species are suitable for use mainly in the categories of construction plywood, inner plies and containers; and it is expected that Peruvian species would find use in those categories. Caoba, aggregated in this group, is a valuable sawn timber in Peru.

In Table A.12 most species with specific gravities between .50 and .60 are presented. This group is composed predominantly of species of brownish and reddish colors, and all species display high hardness values. Most foreign species in this group are used in almost all four categories of plywood manufacture. Peruvian species in this group would find potential use in those categories, but because of their higher hardness values compared with previous groups, and attractive color and figure, they would be more suited for use as decorative veneers.

Tables A.13 and A.14 (Appendix 1) list the results of two groups which classified only Peruvian species with specific gravities over .60. All species have very high strength values, especially for hardness. Unless species with these features have attractive color

and figure, slicing them is inappropriate because the main use of veneers produced by slicing methods is decorative.

Some of these timbers undoubtedly show great potential for use as decorative veneer and it is reported that some have already been used for this purpose (TRADA 1979; Arostegui 1982).

Species grouping based on strength properties has already been adopted. Bolza and Keating (1972) and Berni *et al.* (1979) report that the system of strength grouping currently used in Australia is based on proposals made by Pearson (1965, 1966). Hansom (1982) indicates that Timber Research and Development Association (TRADA) has also developed a grouping system for tropical species based on density (specific gravity) and mechanical properties. Clarke (1937); Longwood (1962); Core (1969); Kukachka (1970); Bendtsen and Chudnoff (1981) have compared properties of tropical timbers with those of hardwoods and conifers from temperate regions.

In this study, the approach focussed on comparing the characteristics of tropical Peruvian species with those of temperate timbers and also with those of tropical timbers from other regions.

With regard to methodology, previous studies have used direct comparisons of properties, and generally on a one-to-one basis. In contrast, this project has applied factor/cluster analysis as an approach to aggregate species with similar characteristics. This technique has proved useful in grouping species with similar qualities and also in reducing the subjective approach when contrasting features directly.

Although many factors besides mechanical properties are determinants in defining the suitability of timber species for veneer and plywood manufacture, this study suggests cluster analysis using specific gravity, modulus of rupture, maximum crushing strength and hardness can give useful preliminary groups of potential species when detailed and more complete data are not available.

5. Growing Stock and Wood Supply

5.1 Current Situation and Data

5.1.1 Forest Inventory Data

Isolated forest resource surveys have been carried out in the country from 1950 to 1971 (ONERN 1972). Most of the studies conducted were made at the reconnaissance and exploratory levels and only about 50.3 thousand hectares were estimated at the semi-detailed and detailed levels.

During the last decade, several other studies have been conducted in the Amazon region mainly at the exploratory level (FAO 1982).

After analysis of the surveyed data for the country, eight partial forest inventories, showing the most reliable results based on adequate sampling intensities, were selected to determine relative abundance of the forest species recorded in those studies (INDUPERU 1981). These records were used as base data in this project. However, separate analysis of the data was necessary to determine the calculated area-weighted average volumes per species.

Apart from this set of data, records of the two latest partial inventories carried out in the vicinity of the Iquitos area were also used in this study. These inventories showed a similar level of accuracy to those mentioned previously. The ten partial inventories used in this study are presented in Table 2.

5.1.2 Forest Type Map

The first forest type map for the country completed in 1975 constituted an important tool for the knowledge and development of the Peruvian forest resources on a macro level. For the Amazon region, productive forests are represented by six types, as mentioned previously. This preliminary information has led to the implementation of

Table 2

List of Partial Inventories Used in the Calculation of Growing Stock

Name	Area ha
1. Informe al Gobierno Peruano sobre el inventario y manejo forestal, conservacion de suelos y manejo de cuencas (Proyecto Huallaga Central) *	36,302
2. Inventario forestal de los bosques de Nueva Italia *	6,000
3. Evaluacion de los recursos forestales de SAIS Pampa (Pucallpa) *	26,507
4. Forest inventory of bosque nacional Alexander von Humboldt *	200,000
5. Proyecto Pozuzo - Peru *	100,000
6. Inventory of the 50,000 ha forest area of Yurimaguas *	50,000
7. Estudio integral de la poblacion de un bosque humedo tropical con fines de ordenacion en la zona de Jenaro Herrera (Iquitos) *	1,500
8. Estudio de factibilidad tecnico economico de los bosques naturales de la zona Challua Yacumishollo *	6,984
9. Evaluacion y lineamientos de manejo de suelos y bosques para el desarollo agrario del area de influencia de la carretera Iquitos - Nauta	89,227
10. Inventario forestal del bosque Santa Cruz (Iquitos)	900

* Eight-inventory base data
Sources of Data: FAO (1975); Villanueva (1976); INDUPERU (1981); DGFF (1981); Villanueva (1982).

current policies on the utilization of the resource in the region. However, further development requires that this introductory stage be complemented by a detailed knowledge of the six productive forest units. This goal has not been accomplished yet and is of primary concern.

Forest productive areas for all forest districts within the Iquitos and Pucallpa regions are found in Table 3 (ORDELORETO 1980).

With the aid of the forest type map information and the partial inventory data, an attempt was made to determine the growing stock of presently used or potentially useful species to the plywood industry.

5.2 Growing Stock

5.2.1 General Background

Growing stock patterns and species composition in tropical forests differ greatly from region to region. Pringle (1976) reports that growing stock in the tropical rain forest of West Africa may vary from 100 to 800 m^3 per hectare. However, the volume of commercial wood removed in logging ranges normally between 5 and 30 m^3 per hectare, with rare cases as high as 60 m^3 per hectare.

In some areas of Southeast Asia, particularly in Sabah and parts of the Philippines and Indonesia, about 80 percent of the stand volume is made up of dipterocarp forests. The volume logged per hectare may average 50 to 60 m^3 with a range of 20 to 100 m^3. In other parts of the region, for example Peninsula Malaysia, the volume extracted is lower and the average is about 40 m^3 per hectare.

The Amazon forests provide a further contrast. They are very complex and heterogeneous, and the volume of commercial wood logged is lower than in Africa and Southeast Asia. The average ranges only from 5 to 10 m^3 per hectare.

Table 3 Productive Accessible Areas by Forest Districts - 1000 ha

Forest District	Alluvial I	Alluvial II	Alluvial III	Hill I	Hill II	Hill III	Total
Atalaya	7.65	80.64	8.550	1521.84	190.82	7.56	1817.060
Caballo Cocha	81.00	31.32	120.420	1419.20	171.50	2.64	1826.080
Contamana	3.06	15.75	52.560	18.56	967.19	9.06	1066.180
Iquitos	2.61	235.62	602.010	1145.36	2045.82	1049.94	5081.360
Nauta	1.80	889.56	37.935	---	---	---	929.295
Pucallpa	25.20	806.58	316.170	683.76	788.06	178.26	2798.030
Putumayo	---	64.26	---	434.40	108.92	---	607.580
Requena	47.70	134.91	115.020	129.28	1933.12	48.24	2408.270
San Lorenzo	563.94	418.14	272.250	128.00	314.72	231.36	1928.410
Yurimaguas	---	382.14	200.070	283.28	170.31	24.78	1060.580
Total	732.96	3058.92	1724.985	5763.68	6690.46	1551.84	19,522,845

In the Amazon region of Peru, the average growing stock ranges from 100 to 140 m^3 per hectare (Malleux 1975). However, the average volume of commercial wood extracted is about 3 m^3 per hectare, and ranges from less than 1 m^3 in some parts of the region[13] to over 15 m^3 (FAO 1979).

5.2.2 Growing Stock Calculation

Based on the analysis of foreign and Peruvian species done in this study, thirty Peruvian species can be considered potential plywood species.

To ascertain whether these species can be available to the industry in sufficient quantities and in continual supply, it is important to know the occurrance and stock volumes of the desired species. In the absence of this information or if a species does not occur in large volumes, it is unlikely that even a species with good technical properties can be used in veneer and plywood production on industrial scale.

Three methods were attempted to determine growing stock and subsequent calculation of years of cut by species.

The first approach intended to estimate for each species average volume per unit area for each of the six forest types, and to extend those figures to the forest type map information in order to calculate the growing stock by species for the Iquitos and Pucallpa regions. Available data for most of the partial inventories either did not present, or provided incomplete estimates on volume per unit area per forest type. Records from the eight-inventory base data used in this study give for each species volume per unit area without considering forest types. It is a summary record, and breaking it down either by forest type or by individual inventory was impossible due to the unavailability of detailed data for most inventories. At this stage, it was only possible to compute for each species volume per unit area per forest type for three inventories applicable to Iquitos area. [14] Estimates for the Pucallpa region were not possible. Lack of sufficient forest type data

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[13] From records of Forest Service (Iquitos, Peru).

[14] They include Iquitos-Nauta, Santa Cruz and Jenaro Herrera.

was a constraint in applying this approach to the calculation of growing stock.

The second criterion attempted to break down data for each species into volume per unit area per public forest in all inventories without considering forest types. It was necessary to know where each inventory was carried out, i.e: what public forest does it apply to. It was also important to determine which inventories elsewhere were applicable to public forests with no past inventory data. If a public forest had more than one inventory carried out within its area, obtaining for each species the average volume per unit area was necessary. At this point, insufficient data applicable to each public forest was the major constraint to apply this criterion. Most partial inventories were not carried out within public forests and most public forests did not have any inventory records at all.

The third approach used data for each species of volume per unit area from the eight-inventory base data set and from the three-inventory base data set. Three sets of estimates were obtained. One series of data resulted from the eight-inventory base data. Another set of data are estimates from the eight-inventory base data minus the von Humboldt inventory data. The criterion used in excluding von Humboldt was based on the assumption that this forest is not a representative area of the total. It is a forest with good stand composition and higher than average volume per unit area. A final set of data consists of estimates from the three inventories applicable to the Iquitos area. These figures were extended to the areas of productive forest lands of Iquitos and Pucallpa regions separately to estimate standing gross volumes by species.

Separate growing stocks by species were calculated for both regions because the industry is concentrated in both regions and each area depends on specific forest districts for its wood supply. Based on geographic location and percentage of wood volumes supplied to the Iquitos region, the public forests included in the districts of Iquitos, Requena and Nauta were used to calculate growing stocks for the region. The three sets of data for each species of volume per unit area were applied in the growing stock calculation for the Iquitos region.

Four forest districts were not included in the determination of growing stocks. The districts of Caballo Cocha and Putumayo, located adjacent to Brazil and Colombia respectively, are the least developed forest areas of the region. Timber supply from these areas to the Iquitos plywood industry is difficult and costly not only for the long distances involved but for the geographical location. Any transportation of wood must be done by barges up the Amazon river. The districts of San Lorenzo and Yurimaguas provide better potential for wood supply to the Iquitos plywood industry for the coming years. Logs can be moved down the Amazon river but the long distances between the logging operations and the mills results in an insignificant amount of timber currently being supplied to Iquitos.

These four districts are potential wood suppliers to the Iquitos plywood industry. Unfortunately, like most forest districts and their corresponding public forests, there is little or no inventory data nor accessibility studies to make them available for forest industry development.

Based also on geographic location and percentage of wood volumes supplied to the Pucallpa region, the public forests included in the districts of Pucallpa, Atalaya and Contamana were used to estimate the standing volumes for the region. Only the two first sets of data for each species of volume per unit area, which give a broad picture of the occurrance of species country-wide, were applied in the growing stock calculation for the Pucallpa region.

5.3 Estimating Supply Potential

In this project, the approach followed to determine the potential cut differs greatly from traditional methods. Incomplete inventory data, unavailable past harvesting records and unknown growth rates make it impractical and impossible to calculate allowable cut based on volume control or area control.

Due to a lack of growth data, determination of sustainable allowable cuts is impossible at this time. For this study however, some idea of the relative abundance or scarcity of the resource was measured by determining the number of years of cut that the existing growing stock could sustain at particular harvest levels. Harvest levels for each region were selected which would supply existing installed capacity and that which would allow a 50 percent expansion of capacity.

The four mills in the Pucallpa region operate with a total approximate capacity of 50 M m^3 annually, and the eight mills in the Iquitos region have a total approximate capacity of 100 M m^3 annually. This latter region undoubtedly presents better conditions for the industry's expansion in the next two decades.

Although the plywood industry in Peru can be considered fairly small in comparison with the neighboring Brazilian industry or the Canadian experience, its actual stage of development can be jeopardized if current policies on timber utilization are not altered. It is consequently of primary concern that the industry adopts an efficient timber supply policy based on adequate qualitative and quantitative knowledge of the forest resource base.

5.4 Results and Discussion

Volume per unit area for each species from the eight-inventory base data are found in Table A.16 (Appendix 2). Twenty six species, out of thirty potential veneer and plywood species, were compiled. Volume figures for four species were omitted after data analysis. Diablo fuerte was omitted because this species occurs only in the high jungle and it was only reported in one inventory. Pashaco was omitted because *Albizzia* spp. was not in any of the inventories. Casho moena was also disregarded because the volume figures under *Ocotea* spp. were taken under a common name other than casho moena. One of the species of huayruro was not recorded in any of the eight-inventory.

The von Humboldt inventory reported 20 species. Values of volume per unit area for only these species were subtracted from their respective values compiled in the eight-inventory base data. Their adjusted area-weighted volumes are listed in Table A.17 (Appendix 2).

The three inventories applicable to the Iquitos region reported only 20 of the thirty potential veneer and plywood species. Their area-weighted volumes are found in Table A.18 (Appendix 2).

Growing stock results for single species are presented in Table A.19 (Appendix 2) for the Iquitos region. In addition, also found are the number of years of cutting remaining before resource exhaustion based on 100 M and 150 M m^3 of installed capacities.

Growing stock figures for the Pucallpa region and the number of years of cutting based on 50 M and 75 M m^3 of production capacities are found in Table A.20 (Appendix 2).

Growing stock figures are widely variable for most species in both regions. Results of the number of years of cutting remaining before resource exhaustion seem to show that the industry does not face wood shortages in either regions and that it can be maintained and/or expanded even considering current selective utilization. However, in the case of lupuna, the chief plywood species in the country, its years of cutting based on current estimates of growing stock clearly show very inconsistent figures for the Iquitos region. By using the three sets of data of volume per unit area and considering the current industry's capacity of 100 M m^3, the industry could be maintained for 93, 115 and 7 years respectively. These estimates differ considerably from the figures obtained for the Pucallpa region, where by using the first and second sets of data of volume per unit area and 50 M m^3 of production capacity, the industry could be maintained for 125 and 155 years. On the other hand, these estimates, especially for the Pucallpa region, differ

greatly from the actual scenario regarding timber supply. A quick survey of the mills,[15] carried out in mid-1982, indicated that the industry had been facing lupuna wood supply shortages particularly in the Pucallpa area. Either the 100 plus year supply of lupuna indicated for the Pucallpa region by the inventories is incorrect or the supply is in areas considered inaccessible by current operators. Due to this problem and the large variation in years of cut indicated for some species, estimates on years of cutting for all species appear to be too suspect for use in planning.

At present, any attempt to determine volumes of standing timber by species, grade and size for sustained industrial development on regional basis is speculative. The basic information on growing stock appears not even reliable enough to evaluate the potentiality of a once-over exploitation of the resource. More sufficient inventory data is required in areas demarcated as permanent productive forests. The total inventory data used in this study covers 517,420 hectares. It represents roughly 3 percent of the accessible productive forests. Most partial inventories were conducted for specific studies and their areas were scattered throughout the Amazon region and not always representative of the entire productive forest land.

This study has found inconclusive results of growing stock estimations based on available data. Although the wood property analysis found potential veneer and plywood species, it is unlikely that at the present these species can be used fully on an industrial scale due to the impossibility of ascertaining their standing volumes within acceptable limits of error.

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[15] Personal communications with mill superintendents by the author.

6. Pricing/Policy Regulations on Stumpage

6.1 Its Effect on Potential Supply of Stumpage

The policy adopted on stumpage pricing has a marked effect in the development of any forest based industry which depends on timber as raw material.

Schmithusen (1977) outlines the difficulties arising in setting up adequate stumpage rates in tropical forestry. Frequently, the stumpage for a particular species is not realistically related to its actual market value and to logging costs. This provides a strong incentive for logging to be highly selective and wasteful because a higher profit on the more valuable species can be made because the stumpage fee does not reflect the relative values of different species.

In Peru, species are grouped in 4 classes and a specific stumpage price is levied on each particular class of species. The classes and stumpage rates are fixed for the whole country.

This current policy leaves the government limited power to positively affect supply. The government has only two alternatives to influence forest utilization with this policy: either species can be moved between classes, or the stumpage price for the classes can be changed. Consequently, the present policy cannot recognize regional differences (public forest differences). Regional differences in transportation costs and individual species supply must be recognized if development is to be based on a concept of renewable supply.

The current stumpage price regulation needs to be revised and possibly modified to recognize regional differences. A possible option is a policy which considers classes of species by public forest and a fixed stumpage price per class for the whole country. In other words, species contained in classes can be different according to public forest and thus, the stumpage price levied for a particular species within a particular class may vary between public forests. Timber supply can be influenced by moving species in

classes based on two important considerations. If species have to be transported long distances, they can be placed in lower classes to create incentive for utilization. On the other hand, species which are short in supply can be placed in higher classes to avoid overcutting of small diameters. The disadvantage of this approach is that public forests that have high transport cost (large transport distances) would tend to have all species in the lowest cost class for stumpage. However, within that class some species would be more valuable and thus, there would be a tendency by harvesters to "high grade" the best species from the class.

A second alternative could also recognize classes of species by public forest and also a specific stumpage price per class by public forest. Again, by placing species in different classes according to public forest, it is possible to control timber supply of species more effectively. Assigning a specific stumpage price per class by public forest also gives the possibility to account for transport and relative values. Following this alternative gives the possibility to place species in classes according to their availability and relative value in each particular public forest. The stumpage price per class per public forest will differ between public forests due to their distance from the manufacturing centers.

Besides having 4 classes and 4 stumpage prices which recognize supply and relative value of timber by public forest, a third alternative could include transportation classes based on accessibility. Two kinds of accessibility could be considered: long distance transport by water and hill forests. Transportation costs are a major element of the overall delivered costs of logs. Therefore, it is important to account for this variable in the assessment of stumpage prices (Gray 1983).

This third alternative gives a more comprehensive policy on stumpage determination and could result in a more effective policy on potential supply of stumpage. In this alternative, the species placed in a particular class in a public forest are levied a stumpage price based not only on transport considerations but also on accessibility.

The current stumpage policy has not been formulated accordingly because public forest differences in species supply and the important parameter of distance have not been applied satisfactorily in its formulation. Stumpage is a very important tool to regulate timber supply to the industry but it has to be realistically used.

7. Conclusions and Recommendations

From the results obtained in this study, the following conclusions and recommendations are provided:

1. Potential veneer and plywood species are available. However, two recommendations of immediate concern are: first, trials on peeling, drying and gluing, either at the research or industrial level, should be given priority to the species found in the first four clusters of this study. Second, the industry needs to evaluate its infrastructure and methods of production.[16] Utilization of potentially useful species on an industrial scale appears to require log conditioning previous to peeling veneer, as it is required by most proven veneer species used for comparison in this study.
2. Current inventory data is insufficient and inadequate to estimate growing stock with acceptable accuracy, and no estimate of growth is available. If estimates of the sustainability of the plywood industry are to be made, sound knowledge of the resource is needed based on a National Forest Inventory. A National Forest Inventory should be made which estimates growing stock and growth by species and by forest type and should account for accessibility.

It is recommended that forest management policy should be guided toward a more reliable and complete knowledge of the resource with regard to current utilization patterns, i.e. to define which areas are supplying the industry. At the present, the plywood industry in Iquitos and Pucallpa is supplied by water transportation in 100 and 95 percent of its wood requirements respectively. Logging operations are primarily confined to the alluvial types and it is assumed that most areas assigned for logging are also located in the alluvial types.

In the Brazilian Amazon, the "varzea forests", which are represented by the alluvial classes II and III, are the main wood supply areas to the industry (Peck 1983). Although the

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[16] Current advances in technology of plywood production are found in Appendix 3.

"varzea forests" comprise only 2.5 percent of the total forest area in the Brazilian Amazon, they are responsible for more than 80 percent of the wood used in the states of Para and Amazonas. These areas present similar physical and geographical characteristics to the Peruvian Amazon. Consequently, alluvial types should be considered priority areas as a first step to a National Forest Inventory.

It is recommended that the newly established Peruvian Amazon Research Institute jointly with the Forest Service and the industry play a decisive role in assessing the forest resource potential in the region and in researching potential peelable species found in this study.

It was beyond the scope of this study to examine the plywood industry growth and development; nevertheless, because utilization of new species is probable in the near future, the following recommendations for future research are stressed:

1. A country-wide marketing study to assess the market response to the introduction of new plywood species is needed.
2. The implementation of product standardization and the necessity to create a quality assurance program built around an association-operated inspection is desirable.
3. The examination of export potential is needed to best utilize the plywood potential of the Peruvian Amazon.

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9. APPENDIX 1

Table A.1 Common and Botanical Names of all Species in this Study

Common Name	Botanical Name
African mahogany	*Khaya ivorensis* A. Chev. and *Khaya* spp.
Aiele	*Canarium schweinfurthii* Engle.
Almendro	*Caryocar coccineum* Pilger
Almendro *	*Caryocar glabrum* (Aubl.) Persoon
American basswood	*Tilia americana* L.
American elm	*Ulmus americana* L.
Balsa	*Ochroma* spp.
Banak	*Virola surinamensis* (Rol) Warb.
Birch	*Betula* spp.
Black ash	*Fraxinus nigra* Marsh.
Black cherry	*Prunus serotina* Ehrh.
Black cottonwood	*Populus trichocarpa* Torr. and Gray
Bonga, ceiba	*Ceiba pentandra* Gaertn.
Cachimbo	*Cariniana domesticata* Mart.
Caimito	*Pouteria* spp.
Caoba	*Swietenia macrophylla* G. King
Carahuasca	*Guatteria decurrens* R. E. Fries
Casho moena	*Ocotea* spp.
Catahua, catahua amarilla	*Hura crepitans* L.
Cativo	*Prioria copaifera* Griseb.
Caucho masha	*Sapium marmieri* Huber
Cedro	*Cedrela odorata* L.
Ceiba	*Ceiba* spp.
Copaiba	*Copaifera officinalis* L.
Copal	*Protium* spp.
Cumala blanca	*Virola* spp.
Charichuelo	*Rheedia* spp.
Chimicua	*Pseudolmedia laevis* (R. et P.) Macbride
Chontaquiro	*Diplotropis martiusii* Benth.
Dark red meranti	*Shorea pauciflora* King.
Diablo fuerte	*Podocarpus oleifolius* Don
Dipterocarp	*Dipterocarpus* spp.
Douglas-fir	*Pseudotsuga menziesii* (Mirb.) Franco
Engelmann spruce	*Picea engelmannii* Parry ex Engelm.
Estoraque	*Myroxylon peruiferum* L.
Huacamayo caspi	*Sickingia* spp.
Hualaja	*Zanthoxylum* spp.
Huayruro	*Ormosia coccinea* (Aubl.) Jacks
Huayruro *	*Ormosia schunkei* Ludd.
Huimba	*Ceiba samauma* (Mart.) K. Schum.

Table A.1 Common and Botanical Names of all Species in this Study -- continued

Common Name	Botanical Name
Ishpingo	*Amburana cearensis* (Fr. Allem.) A. C. Smith
Jelutong	*Dyera costulata* Hook f.
Kapur	*Dryobalanops* spp.
Keruing	*Dipterocarpus* spp.
Lagarto caspi	*Calophyllum brasiliense* Cambers.
Light red meranti	*Shorea parvifolia* Dyer
Lignum vitae	*Guaiacum* spp.
Loblolly pine	*Pinus taeda* L.
Lodgepole pine	*Pinus contorta* Dougl. ex Loud.
Longleaf pine	*Pinus palustris* Mill.
Lupuna, lupuna blanca	*Chorisia integrifolia* Ulbr.
Machimango blanco	*Eschweilera* spp.
Machin sapote	*Matisia bicolor* Ducke
Makore	*Tieghemella heckelii* Hutch. and Dalz.
Manchinga	*Brosimum uleanum* Mildbr.
Manchinga *	*Brosimum* spp.
Maquizapa nagcha	*Apeiba aspera* Aubl.
Maquizapa nagcha *	*Apeiba membranacea* Spruce ex Benth.
Marupa	*Simarouba amara* Aubl.
Mashonaste	*Clarisia racemosa* R. et P.
Mauritia	*Mauritia* spp.
Mersawa	*Anisoptera* spp.
Mijao, caracoli	*Anacardium excelsum* (Bert. et Balb) Skeels
Moena amarilla	*Aniba amazonica* (Meis) Mez.
Moena negra	*Nectandra* spp.
Muritinga	*Maquira* spp.
Niangon	*Tarrietia utilis* Sprague.
Obeche	*Triplochiton scleroxylon* K. Schum.
Okoume, gaboon	*Aucoumea klaineana* Pierre.
Palisangre	*Pterocarpus* spp.
Palosangre amarillo	*Pterocarpus* spp.
Palosangre negro	*Pterocarpus* spp.
Panguana	*Brosimum utile* (H.B.K.) Pittier
Pashaco	*Albizzia* spp.
Paujil ruro	*Pterygota* spp.
Pine	*Pinus* spp.
Ponderosa pine	*Pinus ponderosa* Dougl. ex Laws.
Poplar	*Populus* spp.
Pumaquiro	*Aspidosperma macrocarpon* Mart.
Punga	*Bombax paraense* Ducke
Quina quina	*Lucuma* spp.
Quinilla colorada	*Manilkara bidentata* (A. DC.) Chev.
Ramin	*Gonystylus bancanus* (Miq.) Kurz
Red alder	*Alnus rubra* Bong.

Table A.1 Common and Botanical Names of all Species in this Study -- continued

Common Name	Botanical Name
Red lauan	*Shorea negrosensis* Foxw.
Red oak	*Quercus rubra* L.
Requia	*Guarea kunthiana* A. Juss.
Rock elm	*Ulmus thomasii* Sarg.
Sachavaca micuna	*Trophis* spp.
Sapele	*Entandrophragma cylindricum* Sprague.
Sapote	*Matisia cordata* Humb. et Bonpl.
Shagbark hickory	*Carya ovata* (Mill.) K. Koch
Shiringa	*Hevea* spp.
Shortleaf pine	*Pinus echinata* Mill.
Sipo	*Entandrophragma utile* Sprague.
Sitka spruce	*Picea sitchensis* (Bong.) Carr.
Slash pine	*Pinus elliottii* Engelm.
Spruce	*Picea* spp.
Sugar maple	*Acer saccharum* Marsh.
Sweetgum	*Liquidambar styraciflua* L.
Tahuari	*Tabebuia serratifolia* (Vahl.) Nicholson
Tamamuri	*Ogcodeia* spp.
Tangile	*Shorea polysperma* Merr.
Tiama	*Entandrophragma angolense* C. DC.
Tornillo	*Cedrelinga catenaeformis* (Ducke) Ducke
Trembling aspen	*Populus tremuloides* Michx.
Ubos	*Spondias mombin* L.
Uchumullaca	*Trichilia* spp.
Ucshaquiro blanco	*Sclerolobium* spp.
Western hemlock	*Tsuga heterophylla* (Raf.) Sarg.
White ash	*Fraxinus americana* L.
White lauan	*Pentacme contorta* Merr.
Yacushapana	*Terminalia oblonga* (R. et P.) Eichler
Yanchama	*Poulsenia armata* (Miq.) Standl.
Yellow birch	*Betula alleghaniensis* Britton
Yellow poplar	*Liriodendron tulipifera* L.
Yutubanco	*Heisteria* spp.

* Same common name for 2 species.

Table A.2 Selected Peruvian Species

Common Name	Botanical Name	Family Name
Almendro	*Caryocar coccineum* Pilger	Caryocaraceae
Almendro *	*Caryocar glabrum* (Aubl.) Persoon	Caryocaraceae
Cachimbo	*Cariniana domesticata* Mart.	Lecythidaceae
Caimito	*Pouteria* spp.	Sapotaceae
Caoba	*Swietenia macrophylla* G. King	Meliaceae
Carahuasca	*Guatteria decurrens* R. E. Fries	Annonaceae
Casho moena	*Ocotea* spp.	Lauraceae
Catahua amarilla	*Hura crepitans* L.	Euphorbiaceae
Caucho masha	*Sapium marmieri* Huber	Euphorbiaceae
Cedro	*Cedrela odorata* L.	Meliaceae
Copaiba	*Copaifera officinalis* L.	Caesalpiniaceae
Copal	*Protium* spp.	Burseraceae
Cumala blanca	*Virola* spp.	Myristicaceae
Charichuelo	*Rheedia* spp.	Guttiferae
Chimicua	*Pseudolmedia laevis* (R. et P.) Macbride	Moraceae
Chontaquiro	*Diplotropis martiusii* Benth.	Papilionaceae
Diablo fuerte	*Podocarpus oleifolius* Don	Podocarpaceae
Estoraque	*Myroxylon peruiferum* L.	Papilionaceae
Huacamayo caspi	*Sickingia* spp.	Rubiaceae
Hualaja	*Zanthoxylum* spp.	Rutaceae
Huayruro	*Ormosia coccinea* (Aubl.) Jacks	Papilionaceae
Huayruro *	*Ormosia schunkei* Ludd.	Papilionaceae
Huimba	*Ceiba samauma* (Mart.) K. Schum.	Bombacaceae
Ishpingo	*Amburana cearensis* (Fr. Allem.) A. C. Smith	Papilionaceae
Lagarto caspi	*Calophyllum brasiliense* Cambers.	Guttiferae
Lupuna blanca	*Chorisia integrifolia* Ulbr.	Bombacaceae
Machimango blanco	*Eschweilera* spp.	Lecythidaceae
Machin sapote	*Matisia bicolor* Ducke	Bombacaceae
Manchinga	*Brosimum uleanum* Mildbr.	Moraceae
Manchinga *	*Brosimum* spp.	Moraceae
Maquizapa nagcha	*Apeiba aspera* Aubl.	Tiliaceae
Maquizapa nagcha *	*Apeiba membranacea* Spruce ex Benth.	Tiliaceae
Marupa	*Simarouba amara* Aubl.	Simaroubaceae
Mashonaste	*Clarisia racemosa* R. et P.	Moraceae

Table A.2 Selected Peruvian Species -- continued

Common Name	Botanical Name	Family Name
Moena amarilla	*Aniba amazonica* (Meis) Mez.	Lauraceae
Moena negra	*Nectandra* spp.	Lauraceae
Palisangre	*Pterocarpus* spp.	Papilionaceae
Palosangre amarillo	*Pterocarpus* spp.	Papilionaceae
Palosangre negro	*Pterocarpus* spp.	Papilionaceae
Panguana	*Brosimum utile* (H.B.K.) Pittier	Moraceae
Pashaco	*Albizzia* spp.	Mimosaceae
Paujil ruro	*Pterygota* spp.	Sterculiaceae
Pumaquiro	*Aspidosperma macrocarpon* Mart.	Apocynaceae
Punga	*Bombax paraense* Ducke	Bombacaceae
Quina quina	*Lucuma* spp.	Sapotaceae
Quinilla colorada	*Manilkara bidentata* (A. DC.) Chev.	Sapotaceae
Requia	*Guarea kunthiana* A. Juss.	Meliaceae
Sachavaca micuna	*Trophis* spp.	Moraceae
Sapote	*Matisia cordata* Humb. et Bonpl.	Bombacaceae
Shiringa	*Hevea* spp.	Euphorbiaceae
Tahuari	*Tabebuia serratifolia* (Vahl.) Nicholson	Bignoniaceae
Tamamuri	*Ogcodeia* spp.	Moraceae
Tornillo	*Cedrelinga catenaeformis* (Ducke) Ducke	Mimosaceae
Ubos	*Spondias mombin* L.	Anacardiaceae
Uchumullaca	*Trichilia* spp.	Meliaceae
Ucshaquiro blanco	*Sclerolobium* spp.	Caesalpiniaceae
Yacushapana	*Terminalia oblonga* (R. et P.) Eichler	Combretaceae
Yanchama	*Poulsenia armata* (Miq.) Standl.	Moraceae
Yutubanco	*Heisteria* spp.	Olacaceae

* Same common name for 2 species.
Sources of Data: Lao (1969); Arostegui (1982); Encarnacion (1983).

Table A.3 Physical Properties of Peruvian Species

Common name	Specific gravity (green volume and ovendry weight)	Green moisture content - Pct.	Shrinkage green to ovendry Pct.			Texture[5]	Grain[6]	Color of sapwood and heartwood	Figure[7]
		Mix[1]	T[2]	R[3]	V[4]				
Almendro	.65	79	9.6	4.4	13.6	M	I	Pale yellow sapwood, yellow heartwood	Mottled and striped figure
Almendro *	.65	77	11.5	5.5	15.7	M	I	Yellowish-white	Concentric arcs, striped figure
Cachimbo	.59	61	7.5	4.9	12.0	M	S-I	Creamy pink sapwood, reddish heartwood	Indistinct mottled figure, concentric arcs
Caimito	.60	58	7.2	4.4	10.8	F	I	Reddish	
Caoba	.43	53	5.5	3.2	8.8	M	S	Reddish	Concentric arcs
Carahuasca	.52	55	8.0	3.9	11.5	C	S	Reddish	Striped
Casho moena	.53	75	8.7	3.7	12.1	M	S	Yellow sapwood, yellowish-brown heartwood	Indistinct stripes
Catahua amarilla	.41	61	5.8	3.5	9.1	M	S-I	Creamy white sapwood, yellowish-brown heartwood	Indistinct ribbon stripe
Caucho masha	.40	60	6.8	3.4	8.9	M	S	Yellowish	Striped
Cedro	.42	70	7.0	3.1	10.5	M	S	Reddish	Concentric arcs

Table A.3 Physical Properties of Peruvian Species -- continued

Common name	Specific gravity (green volume and ovendry weight)	Green moisture content - Pct.	Shrinkage green to ovendry Pct.			Texture[5]	Grain[6]	Color of sapwood and heartwood	Figure[7]
		Mix[1]	T[2]	R[3]	V[4]				
Copaiba	.60	55	7.0	3.4	10.2	M	S-I	Red-pink sapwood, yellowish-red heartwood	Distinct concentric arcs, striped
Copal	.61	108	9.7	4.7	13.0	M	S-I	Pale buff to pinkish sapwood, brown or reddish-brown heartwood	Striped
Cumala blanca	.45	89	9.9	4.5	13.4	M	S	Grayish-brown	
Charichuelo	.60	71	12.4	3.9	15.4	M	I	Yellowish	Striped
Chimicua	.70	39	10.3	4.8	14.6	M	I	Yellow sapwood, light brown heartwood	Concentric arcs, indistinctive striped figure
Chontaquiro	.74	48	6.1	4.1	10.6	C	I	Brown	
Diablo fuerte	.53	115	6.1	3.2	9.1	F	S	Yellowish-tan sapwood, reddish-brown heartwood	Distinctive striped
Estoraque	.78	30	6.5	4.2	10.4	M	I	Pale brown sapwood, purple red heartwood	Conspicuous mottled and striped figure
Huacamayo caspi	.65	55	9.9	4.0	13.0	F	S	Reddish	Striped
Hualaja	.47	76	8.0	4.3	11.4	M	S	Yellowish	Striped
Huayruro	.60	74	6.4	3.2	9.3	C	I	Pale brown sapwood, reddish-yellow heartwood	Striped

Table A.3 Physical Properties of Peruvian Species -- continued

Common name	Specific gravity (green volume and ovendry weight)	Green moisture content - Pct.	Shrinkage green to ovendry Pct.			Texture[5]	Grain[6]	Color of sapwood and heartwood	Figure[7]
		Mix[1]	T[2]	R[3]	V[4]				
Huayruro *	.57	87	7.9	3.7	10.5	C	I	Reddish	Striped
Huimba	.56	87	7.5	4.1	11.3	C	S	White sapwood, yellowish-red heartwood	Striped and mottled figure
Ishpingo	.43	--	4.1	2.3	7.6	C	I	Dark yellow to light brown	Concentric arcs, striped figure
Lagarto caspi	.51	50	7.1	4.8	12.3	M-C	I	Yellowish-pink to reddish-brown heartwood, sapwood lighter in colour	Striped
Lupuna blanca	.28	133	9.0	3.1	10.7	M	S	Whitish	None
Machimango blanco	.72	56	8.3	5.4	12.9	M	S	Whitish	
Machin sapote	.52	84	10.7	5.1	14.6	M	S	White to creamy-yellow	Mottled figure
Manchinga	.68	44	8.1	5.0	12.7	M	S-I	Creamy sapwood, yellowish-tan heartwood	Concentric arcs, not distinctively striped
Manchinga *	.68	52	8.0	4.3	12.0	F	I	Whitish	
Maquizapa nagcha	.30	80	6.3	2.3	8.4	C	S	White sapwood, pale yellow heartwood	Indistinctive figure

Table A.3 Physical Properties of Peruvian Species -- continued

Common name	Specific gravity (green volume and ovendry weight)	Green moisture content - Pct.	Shrinkage green to ovendry Pct.			Texture[5]	Grain[6]	Color of sapwood and heartwood	Figure[7]
		Mix[1]	T[2]	R[3]	V[4]				
Maquizapa nagcha *	.27	113	6.7	2.6	8.4	C	S	White sapwood, pale yellow heartwood	Indistinctive figure
Marupa	.36	61	6.7	2.9	9.4	M	S	White sapwood, light yellow heartwood	Dimpled figure
Mashonaste	.59	94	6.3	2.8	8.4	M	I	Yellowish	Concentric arcs
Moena amarilla	.56	--	9.0	4.3	9.4	M	I	Yellowish	Striped
Moena negra	.41	60	5.9	2.7	8.4	M	S-I	Light yellow sapwood, brownish-yellow heartwood	Striped
Palisangre	.70	64	6.5	3.8	9.9	F	I	Reddish	Concentric arcs
Palosangre amarillo	.71	45	10.1	5.6	15.1	C	I	Pale yellow sapwood, pale brown heartwood	Concentric arcs, striped figure
Palosangre negro	.72	61	4.8	2.7	7.4	M	S-I	Pale yellow sapwood, dark yellowish-brown heartwood	Concentric arcs, striped figure
Panguana	.48	62	6.9	3.7	10.4	M	S-I	Creamy-yellow	Striped
Pashaco	.45	95	7.3	3.2	9.5	C	I	Whitish-red	Concentric arcs
Paujil ruro	.62	63	9.3	4.2	12.8	M	I	Whitish	Striped
Pumaquiro	.67	68	8.0	4.1	11.8	F	I	Yellow sapwood,	Concentric arcs,

Table A.3 Physical Properties of Peruvian Species -- continued

Common name	Specific gravity (green volume and ovendry weight)	Green moisture content - Pct.	Shrinkage green to ovendry Pct.			Texture[5]	Grain[6]	Color of sapwood and heartwood	Figure[7]
		Mix[1]	T[2]	R[3]	V[4]				
								reddish-yellow heartwood	striped figure
Punga	.39	94	10.0	3.6	12.9	C	S	Creamy white	None
Quina quina	.74	53	10.0	5.1	14.2	F	I	Reddish	
Quinilla colorada	.87	46	11.0	6.8	15.8	F	S	Reddish	
Requia	.60	79	10.1	5.6	14.9	M	S	Reddish	Concentric arcs
Sachavaca micuna	.44	96	9.4	3.2	11.5	C	I	Yellowish-red	Concentric arcs, striped
Sapote	.43	111	9.0	3.8	11.8	M	S	Yellowish-white	Mottled figure
Shiringa	.53	73	6.8	3.0	9.0	C	I	Reddish	Concentric arcs
Tahuari	.92	34	8.9	5.7	13.9	F	I	Brown	Concentric arcs
Tamamuri	.66	53	8.3	4.9	12.5	M	I	Whitish	Striped
Tornillo	.44	83	6.9	3.2	9.9	C	I	Pink sapwood, reddish heartwood	Striped
Ubos	.35	113	7.4	3.2	10.0	M	S	White sapwood, creamy yellow heartwood	Faint stripes
Uchumullaca	.69	57	10.0	6.4	15.3	F	I	Reddish	

Table A.3 Physical Properties of Peruvian Species -- continued

Common name	Specific gravity (green volume and ovendry weight)	Green moisture content - Pct.	Shrinkage green to ovendry Pct.			Texture[5]	Grain[6]	Color of sapwood and heartwood	Figure[7]
		Mix[1]	T[2]	R[3]	V[4]				
Ucshaquiro blanco	.38	64	6.6	3.4	9.8	C	I	Pinkish sapwood, light brown heartwood	
Yacushapana	.73	40	8.6	4.9	12.3	M	I	Yellowish	Concentric arcs, striped figure
Yanchama	.44	76	7.0	4.5	10.8	M	I	Yellowish	Striped
Yutubanco	.71	59	11.0	5.1	14.6	F	S	Yellowish	

[1] Mix=Average sapwood and heartwood green moisture content
[2] T=Tangential shrinkage
[3] R=Radial shrinkage
[4] V=Volumetric shrinkage
[5] F=Fine, M=Medium, C=Coarse
[6] S=Straight, I=Interlocked
[7] Figure patterns not obtained from veneer
* Same common name for 2 species
Sources of Data: Arostegui y Acevedo (1971/1974); TRADA (1979); Arostegui *et al.* (1980/1981); JUNAC (1981a, 1981c); Arostegui (1982).

Table A.4 Mechanical Properties[1] of Peruvian Species

Common Name	Modulus of elasticity t/cm^2	Modulus of rupture kg/cm^2	Compression parallel to the grain - maximum crushing strength kg/cm^2	Hardness (side) kg	Shear parallel to grain maximum shearing strength kg/cm^2
Almendro	146	713	332	606	102
Almendro *	132	687	320	583	98
Cachimbo	132	716	343	467	85
Caimito	123	765	403	546	110
Caoba	94	524	292	298	68
Carahuasca	123	620	328	375	72
Casho moena	118	581	328	364	87
Catahua amarilla	70	402	184	230	52
Caucho masha	94	403	209	136	47
Cedro	72	395	148	273	58
Copaiba	110	713	359	587	110
Copal	116	734	322	517	103
Cumala blanca	106	447	209	212	52
Charichuelo	124	717	340	552	84
Chimicua	161	905	453	762	124

Table A.4 Mechanical Properties[1] of Peruvian Species -- continued

Common Name	Modulus of elasticity t/cm^2	Modulus of rupture kg/cm^2	Compression parallel to the grain - maximum crushing strength kg/cm^2	Hardness (side) kg	Shear parallel to grain maximum shearing strength kg/cm^2
Chontaquiro	148	997	559	915	149
Diablo fuerte	99	608	302	425	99
Estoraque	167	1299	700	1187	148
Huacamayo caspi	131	829	328	670	104
Hualaja	97	551	299	361	73
Huayruro	134	843	443	661	113
Huayruro *	122	706	279	561	85
Huimba	105	582	287	360	74
Ishpingo	94	739	421	358	52
Lagarto caspi	111	734	319	403	88
Lupuna blanca	47	232	125	120	28
Machimango blanco	133	923	462	834	106
Machin sapote	131	552	262	352	67
Manchinga	117	782	367	714	78
Manchinga *	123	874	438	741	123
Maquizapa nagcha	53	279	159	157	32

Table A.4 Mechanical Properties[1] of Peruvian Species -- continued

Common Name	Modulus of elasticity t/cm^2	Modulus of rupture kg/cm^2	Compression parallel to the grain - maximum crushing strength kg/cm^2	Hardness (side) kg	Shear parallel to grain maximum shearing strength kg/cm^2
Maquizapa nagcha *	45	272	152	131	32
Marupa	77	427	201	204	64
Mashonaste	139	926	536	690	100
Moena amarilla	130	699	379	430	87
Moena negra	93	539	270	291	77
Palisangre	139	1102	547	1052	135
Palosangre amarillo	156	890	445	863	122
Palosangre negro	138	1050	516	1025	132
Panguana	102	514	265	380	78
Pashaco	91	508	273	334	82
Paujil ruro	146	859	441	620	110
Pumaquiro	148	955	522	739	122
Punga	78	348	169	205	42
Quina quina	164	897	435	795	110
Quinilla colorada	184	1204	608	1090	135
Requia	154	750	384	579	93

Table A.4 Mechanical Properties[1] of Peruvian Species -- continued

Common Name	Modulus of elasticity t/cm²	Modulus of rupture kg/cm²	Compression parallel to the grain - maximum crushing strength kg/cm²	Hardness (side) kg	Shear parallel to grain maximum shearing strength kg/cm²
Sachavaca micuna	98	511	267	286	62
Sapote	89	488	239	272	55
Shiringa	92	472	238	306	72
Tahuari	198	1436	786	1403	152
Tamamuri	140	874	437	596	115
Tornillo	109	579	287	388	88
Ubos	80	400	204	199	54
Uchumullaca	134	837	384	706	106
Ucshaquiro blanco	91	488	238	305	69
Yacushapana	127	807	472	768	111
Yanchama	79	500	288	283	69
Yutubanco	142	871	426	757	99

[1] Results based on small, clear specimens in the green condition.
* Same common name recorded for 2 species
Sources of Data: Arostegui y Acevedo (1971/1974); JUNAC (1981c); Arostegui (1982).

Table A.5 Selected Foreign Species

Common name	Botanical name	Family	Origin
African mahogany	*Khaya ivorensis* A. Chev.	Meliaceae	AF
Aiele	*Canarium schweinfurthii* Engle.	Burseraceae	AF
American basswood	*Tilia americana* L.	Tiliaceae	NA
American elm	*Ulmus americana* L.	Ulmaceae	NA
Banak	*Virola surinamensis* (Rol) Warb.	Myristicaceae	SA
Black ash	*Fraxinus nigra* Marsh.	Oleaceae	NA
Black cherry	*Prunus serotina* Ehrh.	Rosaceae	NA
Black cottonwood	*Populus trichocarpa* Torr. and Gray	Salicaceae	NA
Bonga, ceiba	*Ceiba pentandra* Gaertn.	Bombacaceae	SA
Dark red meranti	*Shorea pauciflora* King.	Dipterocarpaceae	SEA
Douglas-fir	*Pseudotsuga menziesii* (Mirb.) Franco	Pinaceae	NA
Engelmann spruce	*Picea engelmannii* Parry ex Engelm.	Pinaceae	NA
Jelutong	*Dyera costulata* Hook f.	Apocynaceae	SEA
Kapur	*Dryobalanops* spp.	Dipterocarpaceae	SEA
Keruing	*Dipterocarpus* spp.	Dipterocarpaceae	SEA
Light red meranti	*Shorea parvifolia* Dyer	Dipterocarpaceae	SEA
Loblolly pine	*Pinus taeda* L.	Pinaceae	NA
Lodgepole pine	*Pinus contorta* Dougl. ex Loud.	Pinaceae	NA
Longleaf pine	*Pinus palustris* Mill.	Pinaceae	NA
Makore	*Tieghemella heckelii* Hutch. and Dalz.	Sapotaceae	AF
Mersawa	*Anisoptera* spp.	Dipterocarpaceae	SEA
Mijao, caracoli	*Anacardium excelsum* (Bert. et Balb) Skeels	Anacardiaceae	SA
Niangon	*Tarrietia utilis* Sprague.	Sterculiaceae	AF
Obeche	*Triplochiton scleroxylon* K. Schum.	Triplochitonaceae	AF
Ponderosa pine	*Pinus ponderosa* Dougl. ex Laws.	Pinaceae	NA
Ramin	*Gonystylus bancanus* (Miq.) Kurz	Gonystylaceae	SEA
Red alder	*Alnus rubra* Bong.	Betulaceae	NA
Red oak	*Quercus rubra* L.	Fagaceae	NA
Red lauan	*Shorea negrosensis* Foxw.	Dipterocarpaceae	SEA
Rock elm	*Ulmus thomasii* Sarg.	Ulmaceae	NA
Sapele	*Entandrophragma cylindricum* Sprague.	Meliaceae	AF
Shagbark hickory	*Carya ovata* (Mill.) K. Koch	Juglandaceae	NA
Shortleaf pine	*Pinus echinata* Mill.	Pinaceae	NA
Sipo	*Entandrophragma utile* Sprague.	Meliaceae	AF
Sitka spruce	*Picea sitchensis* (Bong.) Carr.	Pinaceae	NA
Sugar maple	*Acer saccharum* Marsh.	Aceraceae	NA

Table A.5 Selected Foreign Species -- continued

Common name	Botanical name	Family	Origin
Sweetgum	*Liquidambar styraciflua* L.	Hamamelidaceae	NA
Tangile	*Shorea polysperma* Merr.	Dipterocarpaceae	SEA
Tiama	*Entandrophragma angolense* C. DC.	Meliaceae	AF
Trembling aspen	*Populus tremuloides* Michx.	Salicaceae	NA
Western hemlock	*Tsuga heterophylla* (Raf.) Sarg.	Pinaceae	NA
White ash	*Fraxinus americana* L.	Oleaceae	NA
White lauan	*Pentacme contorta* Merr.	Dipterocarpaceae	SEA
Yellow birch	*Betula alleghaniensis* Britton	Betulaceae	NA
Yellow poplar	*Liriodendron tulipifera* L.	Magnoliaceae	NA

AF=Africa
NA=North America
SA=South America
SEA=Southeast Asia
Sources of Data: TRADA (1979); Panshin and De Zeeuw (1980).

Table A.6 Physical Properties of Foreign Species

Common names	Specific gravity (green volume and ovendry weight)	Green moisture content - Pct.			Shrinkage green to ovendry Pct.			Texture[7]	Grain[8]
		Sap[1]	Mix[2]	Heart[3]	T[4]	R[5]	V[6]		
African mahogany	.43		70		5.6	3.2	--	M-C	S-I
Aiele	.45		--		8.0	5.0	13.5	C	I
American basswood	.32	130		80	9.3	6.6	15.8	F	S
American elm	.46	90		100	9.5	4.2	14.6	C	S-I
Banak	.42		94		8.8	4.6	13.7	M-C	S
Black ash	.45			90	7.8	5.0	15.2	C	S
Black cherry	.47			60	7.1	3.7	11.5	F	S
Black cottonwood	.31	150		160	8.6	3.6	12.4	F	S
Bonga, ceiba	.21		132		4.1	2.3	6.2	M	S
Dark red meranti	.50		62		7.9	3.8	13.3 *	C	I-S
Douglas-fir	.45	110 to 120		30 to 40	7.8	5.0	11.8	M-C	S
Engelmann spruce	.33	140 to 170		40 to 50	6.6	3.4	10.4	M-F	S
Jelutong	.36		61		--	--	--	F	S

Table A.6 Physical Properties of Foreign Species -- continued

Common names	Specific gravity (green volume and ovendry weight)	Green moisture content - Pct. Sap[1]	Mix[2]	Heart[3]	Shrinkage green to ovendry Pct. T[4]	R[5]	V[6]	Texture[7]	Grain[8]
Kapur	.64	--	--	--	10.2	4.6	--	C	S-I
Keruing	.59		60		10.9	5.2	--	C	S
Light red meranti	.39		68		8.5	4.6	14.3 *	C	I-S
Loblolly pine	.47	80 to 140		30 to 40	7.4	4.8	12.3	M	S
Lodgepole pine	.40	120		40	6.8	4.7	11.4	M	S
Longleaf pine	.54	70 to 130		30 to 50	7.5	5.1	12.2	M	S
Makore	.54		60		7.8	5.3	--	F	S
Mersawa	.51		104		8.8	3.7	--	C	I
Mijao, caracoli	.34		74		4.4	2.7	7.0	C	S-I
Niangon	.56		70		5.9	2.9	--	M	I
Obeche	.33		70 to 140		5.3	3.1	--	M-C	I
Ponderosa pine	.38	120 to 150		30 to 40	6.3	3.9	9.6	C	S

Table A.6 Physical Properties of Foreign Species -- continued

Common names	Specific gravity (green volume and ovendry weight)	Green moisture content - Pct.			Shrinkage green to ovendry Pct.			Texture[7]	Grain[8]
		Sap[1]	Mix[2]	Heart[3]	T[4]	R[5]	V[6]		
Ramin	.59		80		8.7	4.3	13.4 *	F	S
Red alder	.37	100			7.3	4.4	12.6	M	S
Red oak	.58	70		50	6.7	3.6	12.0	C	S
Red lauan	.44		--		7.6	3.8	--	C	I
Rock elm	.57	60		40	8.1	4.8	14.1	F	S-I
Sapele	.60		60		8.5	5.7	--	F	I
Shagbark hickory	.64	50		70	10.5	7.0	16.7	C	S
Shortleaf pine	.47	70 to 180		30 to 50	7.7	4.4	12.3	M	S
Sipo	.57		--		6.4	4.6	11.0	M	I
Sitka spruce	.37	140		40	7.5	4.3	11.5	M	S
Sugar maple	.60	90		80	8.8	4.6	15.7	F	S
Sweetgum	.46	140		80 to 120	10.2	5.3	15.0	F	I
Tangile	.46		--		8.5	4.5	--	C	I
Tiama	.50		--		9.0	7.2	--	M-C	I

Table A.6 Physical Properties of Foreign Species -- continued

Common names	Specific gravity (green volume and ovendry weight)	Green moisture content - Pct.			Shrinkage green to ovendry Pct.			Texture[7]	Grain[8]
		Sap[1]	Mix[2]	Heart[3]	T[4]	R[5]	V[6]		
Trembling aspen	.37	110		70	6.6	3.6	11.8	F	S
Western hemlock	.42	80 to 230		40 to 220	7.9	4.3	11.9	M-F	S
White ash	.55	40		50	7.8	4.9	13.4	C	S
White lauan	.43		--		7.6	3.9	--	C	I
Yellow birch	.55	70		70	9.5	7.3	16.7	M	S
Yellow poplar	.40	110		80	8.2	4.6	12.3	F	S

[1] Sap=Sapwood
[2] Mix=Average sapwood and heartwood green moisture content
[3] Heart=Heartwood
[4] T=Tangential shrinkage
[5] R=Radial shrinkage
[6] V=Volumetric shrinkage
[7] F=Fine; M=Medium; C=Coarse
[8] S=Straight; I=Interlocked
* Shrinkage values are for a group of species under the same common name.
Sources of Data: Kukachka (1970); Lutz (1972); USDA (1974); IUFRO (1976); Okoh (1977); Chudnoff (1980); Panshin and De Zeeuw (1980); Mullins and McKnight (1981); JUNAC (1981a, 1981b).

Table A.7 Mechanical Properties[1] of Foreign Species

Common Name	Modulus of elasticity t/cm^2	Modulus of rupture kg/cm^2	Compression parallel to the grain - maximum crushing strength kg/cm^2	Hardness (side) kg	Shear parallel to grain maximum shearing strength kg/cm^2
African mahogany	82	520	246	291	65
Aiele	68	394	211	236	58
American basswood	73	352	156	114	42
American elm	78	506	205	281	70
Banak	115	394	168	145	51
Black ash	73	422	162	236	60
Black cherry	92	562	249	300	79
Black cottonwood	76	345	155	114	43
Bonga, ceiba	27	181	95	74	29
Dark red meranti	105	661	332	318	78
Douglas-fir	110	541	266	227	63
Engelmann spruce	72	330	153	118	45
Jelutong	82	394	214	150	53
Kapur	120	858	420	445	73
Keruing	126	648	310	363	73

Table A.7 Mechanical Properties[1] of Foreign Species -- continued

Common Name	Modulus of elasticity t/cm^2	Modulus of rupture kg/cm^2	Compression parallel to the grain - maximum crushing strength kg/cm^2	Hardness (side) kg	Shear parallel to grain maximum shearing strength kg/cm^2
Light red meranti	73	467	234	200	50
Loblolly pine	98	513	247	204	60
Lodgepole pine	89	401	201	150	51
Longleaf pine	112	598	304	268	73
Makore	90	728	358	422	96
Mersawa	101	531	266	368	70
Mijao, caracoli	58	378	177	146	50
Niangon	92	681	358	477	90
Obeche	50	361	181	191	47
Ponderosa pine	70	359	172	145	49
Ramin	111	688	379	291	70
Red alder	82	457	208	200	54
Red oak	110	661	277	454	96
Red lauan	97	541	260	259	65
Rock elm	84	668	266	427	89
Sapele	105	715	352	463	88

Table A.7 Mechanical Properties[1] of Foreign Species -- continued

Common Name	Modulus of elasticity t/cm²	Modulus of rupture kg/cm²	Compression parallel to the grain - maximum crushing strength kg/cm²	Hardness (side) kg	Shear parallel to grain maximum shearing strength kg/cm²
Shagbark hickory	110	773	322	640	107
Shortleaf pine	98	520	248	200	64
Sipo	105	761	374	490	97
Sitka spruce	86	401	188	159	53
Sugar maple	120	717	321	440	114
Sweetgum	84	499	214	272	70
Tangile	108	584	277	281	66
Tiama	75	501	248	350	66
Trembling aspen	92	387	165	136	51
Western hemlock	92	464	236	186	60
White ash	101	675	281	436	97
White lauan	97	527	260	263	64
Yellow birch	105	584	238	354	78
Yellow poplar	86	422	187	200	56

[1] Results based on small, clear specimens in the green condition.
Sources of Data: Kukachka (1970); Lutz (1972); USDA (1974); Mullins and McKnight (1981); JUNAC (1981b)

Table A.8 Additional Information for Foreign Species *

Common name	Bolt conditioning[1]	Ease - Cutting[2]	Dry veneer[3]	Color and figure of veneer: Rotary or flat sliced	Color and figure of veneer: Quarter or rift sliced
African mahogany	65	A	A	Color ranges from pink to dark brown, medium texture, variable grain	
Aiele	55	A	B	White in color, coarse texture, numerous pin knots	
American basswood	5-20	B	A	Pale yellow-brown sometimes reddish, faint growth ring	No figure
American elm	50-60	B	B	Light gray-brown-reddish tinge, conspicuous growth ring	Fine growth lines, small ray flakes sometimes interlocked
Banak	25-80	B	B	Pinkish, golden brown or deep reddish-brown straight medium to coarse grain	
Black ash	50-60	B	A	Moderately dark brown, conspicuous growth rings	Distinct not conspicuous growth ring stripe
Black cherry	50-60	B	A	Light to dark red-brown, moderate growth ring	Small, numerous light colored rays
Black cottonwood	5-20	B	C	Gray-white to light brown, no figure	Sometimes cross grain
Bonga, ceiba	25	A	A	Light grayish brown with pinkish cast, straight but rather coarse grain	
Dark red meranti	85	A	A	Red brown or dark red,	Interlocked and wavy grain.

Table A.8 Additional Information for Foreign Species -- continued

Common name	Bolt conditioning[1]	Ease - Cutting[2]	Dry veneer[3]	Color and figure of veneer	
				Rotary or flat sliced	Quarter or rift sliced
				sapwood yellowish-brown. Texture medium to coarse but even. Concentric bands of resin canals.	Striped figure
Douglas-fir	15-60	B	A	Orange-red sometimes yellow, conspicuous growth ring	Distinct not conspicuous growth ring stripe
Engelmann spruce	20-50	B	B	Nearly white with a faint growth ring	None
Jelutong	---	A	B	Pale straw color. Sapwood not differentiated by col- or. Surface lustrous with out any figure. Texture fine and even. Straight grain, slit-like radial passages (latex traces) which may be seen on tangential surface as lens shaped bodies	
Kapur	above 90	B	B	Pale reddish-brown to reddish-brown	
Keruing	85	A B	B B	Brown, coarse texture fibrous surface	
Light red meranti	15	A	A	Light red or pink brown. Sapwood of distinct lighter color. Texture coarse but even. Concentric bands of resin canals.	Interlocked and wavy grain. Striped figure
Loblolly pine	50-70	B	B	Nearly white sapwood,	Distinct not conspicuous

Table A.8 Additional Information for Foreign Species -- continued

Common name	Bolt conditioning[1]	Ease - Cutting[2]	Dry veneer[3]	Color and figure of veneer	
				Rotary or flat sliced	Quarter or rift sliced
				orange to red-brown heartwood and conspicuous growth ring	growth ring stripe
Lodgepole pine	55	B	B	Nearly white sapwood, light yellow to yellowish brown heartwood, distinct not conspicuous growth ring	None
Longleaf pine	50-70	B	B	Nearly white sapwood, orange to red-brown heartwood and conspicuous growth ring	Distinct not conspicuous growth ring stripe
Makore	85	A	B	Pinkish-brown to dark red, fine texture, grain variable	
Mersawa	---	A	B	Yellow-brown darkening on exposure to straw-brown. Texture moderately coarse but even. Interlocked grain	
Mijao, caracoli	25	A	B	Pale pink with golden streaks, coarse grain	
Niangon	70	A	B	Reddish-brown, medium texture, grain irregular	
Obeche	15	A	A	Pale straw, coarse texture, no prominent features	
Ponderosa pine	15-60	A	A	Creamy white sapwood, orange to red brown	Faint growth ring stripe

Table A.8 Additional Information for Foreign Species -- continued

Common name	Bolt conditioning[1]	Ease - Cutting[2]	Dry veneer[3]	Color and figure of veneer	
				Rotary or flat sliced	Quarter or rift sliced
				heartwood, distinct growth ring	
Ramin	85	A	A	Pale straw, fine texture, straight grain	
Red alder	25-50	A	A	Pale pink-brown, faint growth ring, large rays	Scattered large flakes sometimes entirely absent
Red oak	70	B	B	Pale brown heartwood with fleshy tinge, paler sapwood, conspicuous growth ring	Pronounced flake (broad rays) distinct not conspicuous growth ring stripe
Red lauan	---	A	B	Reddish to dark red, wood with interlocking grain	
Rock elm	70-75	B	B	Light brown to brown with reddish tinge, conspicuous growth ring	Fine growth lines, small ray flakes sometimes interlocked
Sapele	85	A	A	Dark reddish-brown, medium texture, irregular wavy outlines of growth rings produce attractive figure	
Shagbark hickory	70-80	C	B	Reddish-brown, distinct not conspicuous growth ring, traumatic darker streaks	Fine rays, faint growth rings, traumatic darker streaks
Shortleaf pine	50-70	B	B	Nearly white sapwood, orange to red-brown heartwood and conspi-	Distinct not conspicuous growth ring stripe

Table A.8 Additional Information for Foreign Species -- continued

Common name	Bolt conditioning[1]	Ease - Cutting[2]	Dry veneer[3]	Color and figure of veneer: Rotary or flat sliced	Color and figure of veneer: Quarter or rift sliced
				cuous growth ring	
Sipo	---	--	-		
Sitka spruce	20-50	B	A	Light red-brown, distinct not conspicuous growth ring	Faint growth ring stripe
Sugar maple	75	B	B	White sapwood, pale reddish-brown heartwood, faint growth ring, occasionally birdseyed, curly and wavy	Occasionally curly and wavy
Sweetgum	50-60	A	B	Reddish-brown, sometimes with irregular dark streaks	Frequently interlocked stripes
Tangile	60-70	A	A	Light sapwood and dark red-brown heartwood. Plain figure	Distinct ribbon
Tiama	---	--	-		
Trembling aspen	5-20	B	B	Almost white sapwood, grayish-brown heartwood, faint growth ring	None
Western hemlock	50-70	B	B	Buff to light brown, distinct not conspicuous growth ring	Faint growth ring stripe
White ash	60-70	B	B	Gray-brown (lighter than black ash), conspicuous	Distinct not conspicuous growth ring stripe

Table A.8 Additional Information for Foreign Species -- continued

Common name	Bolt conditioning[1]	Ease - Cutting[2]	Dry veneer[3]	Color and figure of veneer: Rotary or flat sliced	Color and figure of veneer: Quarter or rift sliced
				growth rings	
White lauan	---	A	B	Grayish, rather dark streaks, interlocking grain, medium grain	
Yellow birch	60-70	B	B	Reddish-brown, distinct not conspicuous growth ring	Faint growth ring stripes, sometimes wavy grain
Yellow poplar	20-50	A	A	Pale yellow-green, occasionally purple-blue-black streaks	Faint growth rings, small ray flakes

[1] The cutting temperature (or range) in °C is that suggested for rotary cutting veneer 3 mm (1/8 in.) in thickness

[2] A = Easy to cut into smooth, tight veneer of uniform thickness
B = Moderately easy to cut into smooth, tight veneer of uniform thickness
C = Difficult to cut into smooth, tight veneer of uniform thickness

[3] Characteristics of dry veneer:
A = Dries flat and split-free
B = Slight to moderate buckle and drying splits
C = Moderate to pronounced buckle and other defects as collapse and splits

* Reproduced from Veneer species of the world (IUFRO 1976) with the permission of Forest Products Laboratory, Forest Service, U.S. Department of Agriculture, Madison, WI 53705.

Table A.9 Cluster Analysis Run Results - Cluster 1

Species	Sp gr[1]	MOE[2] t/cm²	MOR[3] kg/cm²	MCS[4] kg/cm²	HARD[5] kg	SHEAR[6] kg/cm²	Shk.[7]	Tex.[8]	Gr.[9]	Col.[10]	Relative suitability[11] for: Const. ply	Dec. face	Inner ply	Cont.
Peruvian														
Lupuna blanca	.28	47	232	125	120	28	B	M	S	Y				
Foreign														
Bonga, ceiba	.21	27	181	95	74	29	A	M	S	Y	C	C	B	C
Black cottonwood	.31	76	345	155	114	43	B	F	S	Y	C	C	B	A
American basswood	.32	73	352	156	114	42	B	F	S	Y	C	C	A	A
Engelmann spruce	.33	72	330	153	118	45	B	M-F	S	Y	B	C	C	A

1 Sp gr = Specific gravity (green volume and ovendry weight)
2 MOE = Modulus of elasticity
3 MOR = Modulus of rupture
4 MCS = Maximum crushing strength - compression parallel to the grain
5 HARD = Hardness (side)
6 SHEAR = Shear parallel to grain - maximum shearing strength
7 Shk. = Width shrinkage (tangential) green to ovendry, of rotary cut veneer (IUFRO 1976):
A = 6.5 pct. shrinkage or less
B = 6.6 to 9.5 pct. shrinkage
C = 9.6 pct. shrinkage or more
8 Tex. = Texture: F=Fine, M=Medium, C=Coarse
9 Gr. = Grain: S=Straight, I=Interlocked

[10] Col. = Color (Wassink 1982):
Y = Yellowish (includes whitish and yellow)
B = Brown (includes yellow brown, brown, reddish brown)
R = Reddish (includes dark red, red, light red)

[11] A = Well suited for this product
B = Moderately well suited for this product
C = Not generally suited for this product

Description of end uses is found in Table A.15

Table A.10 Cluster Analysis Run Results - Cluster 2

Species	Sp gr[1]	MOE[2] t/cm²	MOR[3] kg/cm²	MCS[4] kg/cm²	HARD[5] kg	SHEAR[6] kg/cm²	Shk.[7]	Tex.[8]	Gr.[9]	Col.[10]	Relative suitability[11] for: Const. ply	Dec. face	Inner ply	Cont.
Peruvian														
Ubos	.35	80	400	204	199	54	B	M	S	Y				
Marupa	.36	77	427	201	204	64	B	M	S	Y				
Punga	.39	78	348	169	205	42	C	C	S	Y				
Caucho masha	.40	94	403	209	136	47	B	M	S	Y				
Catahua amarilla	.41	70	402	184	230	52	A	M	S-I	Y				
Cedro	.42	72	395	148	273	58	B	M	S	R				
Cumala blanca	.45	106	447	209	212	52	C	M	S	B				
Foreign														
Obeche	.33	50	361	181	191	47	A	M-C	I	Y	C	C	A	C
Mijao, caracoli	.34	58	378	177	146	50	A	C	S-I	Y	C	C	B	C
Jelutong	.36	82	394	214	150	53	B	F	S	Y	C	C	A	C
Red alder	.37	82	457	208	200	54	B	M	S	B	C	B	A	B
Sitka spruce	.37	86	401	188	159	53	B	M	S	Y	B	B	B	A

Table A.10 Cluster Analysis Run Results - Cluster 2 (continued)

Species	Sp gr[1]	MOE[2] t/cm²	MOR[3] kg/cm²	MCS[4] kg/cm²	HARD[5] kg	SHEAR[6] kg/cm²	Shk.[7]	Tex.[8]	Gr.[9]	Col.[10]	Relative suitability[11] for: Const. ply	Dec. face	Inner ply	Cont.
Foreign														
Trembling aspen	.37	92	387	165	136	51	B	F	S	Y	C	B	A	A
Ponderosa pine	.38	70	359	172	145	49	A	C	S	Y	B	A	B	A
Light red meranti	.39	73	467	234	200	50	B	C	I-S	R	B	B	A	A
Lodgepole pine	.40	89	401	201	150	51	B	M	S	Y	A	C	B	C
Yellow poplar	.40	86	422	187	200	56	B	F	S	Y	B	B	A	A
Banak	.42	115	394	168	145	51	B	M-C	S	B	B	C	A	B
Western hemlock	.42	92	464	236	186	60	B	M-F	S	Y	A-B	C	B	A
Black ash	.45	73	422	162	236	60	B	C	S	B	B	A	B	A
Aiele	.45	68	394	211	236	58	B	C	I	Y	C	C	A	A

[1] Sp gr = Specific gravity (green volume and ovendry weight)
[2] MOE = Modulus of elasticity
[3] MOR = Modulus of rupture
[4] MCS = Maximum crushing strength - compression parallel to the grain
[5] HARD = Hardness (side)
[6] SHEAR = Shear parallel to grain - maximum shearing strength

[7] Shk. = Width shrinkage (tangential) green to ovendry, of rotary cut veneer (IUFRO 1976):
A = 6.5 pct. shrinkage or less
B = 6.6 to 9.5 pct. shrinkage
C = 9.6 pct. shrinkage or more

[8] Tex. = Texture: F=Fine, M=Medium, C=Coarse

[9] Gr. = Grain: S=Straight, I=Interlocked

[10] Col. = Color (Wassink 1982):
Y = Yellowish (includes whitish and yellow)
B = Brown (includes yellow brown, brown, reddish brown)
R = Reddish (includes dark red, red, light red)

[11] A = Well suited for this product
B = Moderately well suited for this product
C = Not generally suited for this product

Description of end uses is found in Table A.15

Table A.11 Cluster Analysis Run Results - Cluster 3

Species	Sp gr[1]	MOE[2] t/cm²	MOR[3] kg/cm²	MCS[4] kg/cm²	HARD[5] kg	SHEAR[6] kg/cm²	Shk.[7]	Tex.[8]	Gr.[9]	Col.[10]	Relative suitability[11] for: Const. ply	Dec. face	Inner ply	Cont.
Peruvian														
Ucshaquiro blanco	.38	91	488	238	305	69	B	C	I	B				
Moena negra	.41	93	539	270	291	77	A	M	S-I	B				
Sapote	.43	89	488	239	272	55	B	M	S	Y				
Caoba	.43	94	524	292	298	68	A	M	S	R				
Pashaco	.45	91	508	273	334	82	B	C	I	R				
Hualaja	.47	97	551	299	361	73	B	M	S	Y				
Panguana	.48	102	514	265	380	78	B	M	S-I	Y				
Machin sapote	.52	131	552	262	352	67	C	M	S	Y				
Shiringa	.53	92	472	238	306	72	B	C	I	R				
Foreign														
White lauan	.43	97	527	260	263	64	B	C	I	B	A	C	B	B
African mahogany	.43	82	520	246	291	65	A	M-C	S-I	B	A	A	A	C

Table A.11 Cluster Analysis Run Results - Cluster 3 (continued)

Species	Sp gr[1]	MOE[2] t/cm²	MOR[3] kg/cm²	MCS[4] kg/cm²	HARD[5] kg	SHEAR[6] kg/cm²	Shk.[7]	Tex.[8]	Gr.[9]	Col.[10]	Relative suitability[11] for: Const. ply	Dec. face	Inner ply	Cont.
Foreign														
Red lauan	.44	97	541	260	259	65	B	C	I	R	A	C	B	B
Douglas-fir	.45	110	541	266	227	63	B	M-C	S	Y	A	C	B	A
American elm	.46	78	506	205	281	70	B	C	S-I	B	B	A	B	A
Sweetgum	.46	84	499	214	272	70	C	F	I	B	B	B	B	A
Tangile	.46	108	584	277	281	66	B	C	I	R	B	A	B	A-B
Shortleaf pine	.47	98	520	248	200	64	B	M	S	Y	A	C	C	B
Loblolly pine	.47	98	513	247	204	60	B	M	S	Y	A	C	C	B
Black cherry	.47	92	562	249	300	79	B	F	S	B	B	A	B	B
Tiama	.50	75	501	248	350	66	B	M-C	I	R				
Mersawa	.51	101	531	266	368	70	B	C	I	B	B	C	A	B
Longleaf pine	.54	112	598	304	268	73	B	M	S	Y	A	C	C	B
Yellow birch	.55	105	584	238	354	78	B	M	S	B	B	A	B	B

[1] Sp gr = Specific gravity (green volume and ovendry weight)

[2] MOE = Modulus of elasticity
[3] MOR = Modulus of rupture
[4] MCS = Maximum crushing strength - compression parallel to the grain
[5] HARD = Hardness (side)
[6] SHEAR = Shear parallel to grain - maximum shearing strength
[7] Shk. = Width shrinkage (tangential) green to ovendry, of rotary cut veneer (IUFRO 1976):
A = 6.5 pct. shrinkage or less
B = 6.6 to 9.5 pct. shrinkage
C = 9.6 pct. shrinkage or more
[8] Tex. = Texture: F=Fine, M=Medium, C=Coarse
[9] Gr. = Grain: S=Straight, I=Interlocked
[10] Col. = Color (Wassink 1982):
Y = Yellowish (includes whitish and yellow)
B = Brown (includes yellow brown, brown, reddish brown)
R = Reddish (includes dark red, red, light red)
[11] A = Well suited for this product
B = Moderately well suited for this product
C = Not generally suited for this product
Description of end uses is found in Table A.15

Table A.12 Cluster Analysis Run Results - Cluster 4

Species	Sp gr[1]	MOE[2] t/cm²	MOR[3] kg/cm²	MCS[4] kg/cm²	HARD[5] kg	SHEAR[6] kg/cm²	Shk.[7]	Tex.[8]	Gr.[9]	Col.[10]	Relative suitability[11] for: Const. ply	Dec. face	Inner ply	Cont.
Peruvian														
Ishpingo	.43	94	739	421	358	52	A	C	I	B				
Lagarto caspi	.51	111	734	319	403	88	B	M-C	I	R				
Carahuasca	.52	123	620	328	375	72	B	C	S	R				
Casho moena	.53	118	581	328	364	87	B	M	S	B				
Diablo fuerte	.53	99	608	302	425	99	A	F	S	B				
Huimba	.56	105	582	287	360	74	B	C	S	R				
Moena amarilla	.56	130	699	379	430	87	B	M	I	Y				
Huayruro (1)	.57	122	706	279	561	85	B	C	I	R				
Cachimbo	.59	132	716	343	467	85	B	M	S-I	R				
Copaiba	.60	110	713	359	587	110	B	M	S-I	B				
Requia	.60	154	750	384	579	93	B	M	S	R				
Huayruro (2)	.60	134	843	443	661	113	A	C	I	B				
Copal	.61	116	734	322	517	103	C	M	S-I	B				

Table A.12 Cluster Analysis Run Results - Cluster 4 (continued)

Species	Sp gr[1]	MOE[2] t/cm²	MOR[3] kg/cm²	MCS[4] kg/cm²	HARD[5] kg	SHEAR[6] kg/cm²	Shk.[7]	Tex.[8]	Gr.[9]	Col.[10]	Relative suitability[11] for: Const. ply	Dec. face	Inner ply	Cont.
Foreign														
Dark red meranti	.50	105	661	332	318	78	B	C	I-S	R	A	A	A	A
Makore	.54	90	728	358	422	96	B	F	S	R	A	A	A	C
White ash	.55	101	675	281	436	97	B	C	S	B	B	A	B	A
Niangon	.56	92	681	358	477	90	A	M	I	B	A	C	C	C
Rock elm	.57	84	668	266	427	89	B	F	S-I	B	B	A	C	A
Sipo	.57	105	761	374	490	97	A	M	I	R				
Red oak	.58	110	661	277	454	96	B	C	S	B	C	A	B	B
Ramin	.59	111	688	379	291	70	B	F	S	B	A	C	A	A
Keruing	.59	126	648	310	363	73	C	C	S	B	A	C	C	C
Sugar maple	.60	120	717	321	440	114	B	F	S	B	C	A	A	A
Sapele	.60	105	715	352	463	88	B	F	I	B	A	B	B	A
Shagbark hickory	.64	110	773	322	640	107	C	C	S	B	B	A	C	B
Kapur	.64	120	858	420	445	73	C	C	S-I	B	A	B	B	B

(1) *Ormosia schunkei* Ludd.
(2) *Ormosia coccinea* (Aubl.) Jacks
[1] Sp gr = Specific gravity (green volume and ovendry weight)

[2] MOE = Modulus of elasticity
[3] MOR = Modulus of rupture
[4] MCS = Maximum crushing strength - compression parallel to the grain
[5] HARD = Hardness (side)
[6] SHEAR = Shear parallel to grain - maximum shearing strength
[7] Shk. = Width shrinkage (tangential) green to ovendry, of rotary cut veneer (IUFRO 1976):
A = 6.5 pct. shrinkage or less
B = 6.6 to 9.5 pct. shrinkage
C = 9.6 pct. shrinkage or more
[8] Tex. = Texture: F=Fine, M=Medium, C=Coarse
[9] Gr. = Grain: S=Straight, I=Interlocked
[10] Col. = Color (Wassink 1982):
Y = Yellowish (includes whitish and yellow)
B = Brown (includes yellow brown, brown, reddish brown)
R = Reddish (includes dark red, red, light red)
[11] A = Well suited for this product
B = Moderately well suited for this product
C = Not generally suited for this product
Description of end uses is found in Table A.15

Table A.13 Cluster Analysis Run Results - Cluster 5

Species	Sp gr[1]	MOE[2] t/cm²	MOR[3] kg/cm²	MCS[4] kg/cm²	HARD[5] kg	SHEAR[6] kg/cm²	Shk.[7]	Tex.[8]	Gr.[9]	Col.[10]
Peruvian										
Mashonaste	.59	139	926	536	690	100	A	M	I	Y
Pumaquiro	.67	148	955	522	739	122	B	F	I	B
Manchinga (1)	.68	123	874	438	741	123	B	F	I	Y
Chimicua	.70	161	905	453	762	124	C	M	I	B
Palisangre	.70	139	1102	547	1052	135	A	F	I	R
Palosangre amarillo	.71	156	890	445	863	122	C	C	I	Y
Yutubanco	.71	142	871	426	757	99	C	F	S	Y
Palosangre negro	.72	138	1050	516	1025	132	A	M	S-I	B
Machimango blanco	.72	133	923	462	834	106	B	M	S	Y
Yacushapana	.73	127	807	472	768	111	B	M	I	Y
Quina quina	.74	164	897	435	795	110	C	F	I	R
Chontaquiro	.74	148	997	559	915	149	A	C	I	B

(1) *Brosimum* spp.

[1] Sp gr = Specific gravity (green volume and ovendry weight)
[2] MOE = Modulus of elasticity
[3] MOR = Modulus of rupture
[4] MCS = Maximum crushing strength - compression parallel to the grain
[5] HARD = Hardness (side)
[6] SHEAR = Shear parallel to grain - maximum shearing strength
[7] Shk. = Width shrinkage (tangential) green to ovendry, of rotary cut veneer (IUFRO 1976):
A = 6.5 pct. shrinkage or less
B = 6.6 to 9.5 pct. shrinkage
C = 9.6 pct. shrinkage or more
[8] Tex. = Texture: F=Fine, M=Medium, C=Coarse
[9] Gr. = Grain: S=Straight, I=Interlocked
[10] Col. = Color (Wassink 1982):
Y = Yellowish (includes whitish and yellow)
B = Brown (includes yellow brown, brown, reddish brown)
R = Reddish (includes dark red, red, light red)

Table A.14 Cluster Analysis Run Results - Cluster 6

Species	Sp gr[1]	MOE[2] t/cm²	MOR[3] kg/cm²	MCS[4] kg/cm²	HARD[5] kg	SHEAR[6] kg/cm²	Shk.[7]	Tex.[8]	Gr.[9]	Col.[10]
Peruvian										
Estoraque	.78	167	1299	700	1187	148	A	M	I	R
Quinilla colorada	.87	184	1204	608	1090	135	C	F	S	R
Tahuari	.92	198	1436	786	1403	152	B	F	I	B

[1] Sp gr = Specific gravity (green volume and ovendry weight)
[2] MOE = Modulus of elasticity
[3] MOR = Modulus of rupture
[4] MCS = Maximum crushing strength - compression parallel to the grain
[5] HARD = Hardness (side)
[6] SHEAR = Shear parallel to grain - maximum shearing strength
[7] Shk. = Width shrinkage (tangential) green to ovendry, of rotary cut veneer (IUFRO 1976):
A = 6.5 pct. shrinkage or less
B = 6.6 to 9.5 pct. shrinkage
C = 9.6 pct. shrinkage or more
[8] Tex. = Texture: F=Fine, M=Medium, C=Coarse
[9] Gr. = Grain: S=Straight, I=Interlocked
[10] Col. = Color (Wassink 1982):
Y = Yellowish (includes whitish and yellow)
B = Brown (includes yellow brown, brown, reddish brown)
R = Reddish (includes dark red, red, light red)

Table A.15 Description of End Uses *

End Use	Typical Specific Uses	Desirable Veneer Qualities
Construction plywood	Building construction as subfloor, wall sheathing, roof sheathing, and concrete form	High stiffness and strength, moderate weight, readily glued
Decorative face veneer	Prefinished decorative wall panels, furniture, flush doors, kitchen cabinets, case goods	Attractive figure and color, moderately hard, readily glued
Inner plies for decorative panels	Inner plies for prefinished wall panels, furniture, flush doors, kitchen cabinets, and case goods	Low weight, low shrinkage, straight grain, fine uniform grain and easily glued
Container veneer and plywood	Wirebound boxes, bushel baskets, paperoverlaid veneer, cleated panel boxes, plywood sheathed crates	High in stiffness, shock resistance, and resistance to splitting, light color free from odor and taste, moderate in weight

* Reproduced from Veneer species of the world (IUFRO 1976) with the permission of Forest Products Laboratory, Forest Service, U.S. Department of Agriculture, Madison, WI 53705

Table A.16 Area-weighted volume per unit area/species
Eight-inventory Base Data

Species	Growing stock m^3	Inventoried area - ha	Volume m^3/ha	Inventory source *
Cachimbo	185,303	186,302	.99	1,5,6
Caoba	143,979	286,302	.50	1,4,6
Carahuasca	247,321	212,809	1.16	1,3,5,6
Catahua	381,353	412,809	.92	1,3,4,5,6
Caucho masha	151,436	228,007	.66	3,4,7
Cedro	56,532	318,809	.18	1,2,3,4,6
Copaiba	549,177	319,793	1.72	1,3,4,6,8
Copal	358,993	414,309	.87	1,3,4,5,6,7
Cumala blanca	1,810,626	427,293	4.24	1,...,8
Huayruro[1]	428,926	414,309	1.04	1,3,4,5,6,7
Hualaja	140,081	292,302	.48	1,2,4,6
Huimba	625,795	412,809	1.52	1,3,4,5,6
Ishpingo	50,986	206,000	.25	2,4
Lagarto caspi	16,664	256,000	0.07	2,4,6
Lupuna	907,173	412,809	2.20	1,3,4,5,6
Machin sapote	135,316	226,507	.60	3,4
Marupa	160,257	312,809	.51	1,3,4,6
Moena amarilla	45,939	14,484	3.17	2,7,8.
Moena negra	85,151	106,984	.80	5,8

Table A.16 Area-weighted volume per unit area/species
Eight-inventory Base Data -- continued

Species	Growing stock m^3	Inventoried area - ha	Volume m^3/ha	Inventory source *
Panguana	595,492	286,302	2.08	1,4,6
Punga	33,105	112,809	.29	1,3,6
Requia	185,384	220,309	.84	1,2,3,5,6,7
Sapote	1,539,642	386,302	3.98	1,4,5,6
Shiringa	611,670	414,309	1.48	1,3,4,5,6,7
Ubos	290,473	312,809	.93	1,3,4,6
Ucshaquiro blanco	256,664	312,809	.82	1,3,4,6

* Inventory source numbers coincide with those on the list of inventories in Table 2
[1] *Ormosia coccinea* (Aubl.) Jacks

Table A.17 Area-weighted volume per unit area/species
Eight-inventory Base Data less
von Humboldt Inventory

Species	Growing stock m^3	Inventoried area - ha	Volume m^3/ha	Inventory source *
Caoba	85,279	86,302	.99	1,6
Catahua	247,853	212,809	1.16	1,3,5,6
Caucho masha	4,636	28,007	.17	3,7
Cedro	26,032	118,809	.22	1,2,3,6
Copaiba	187,377	119,793	1.56	1,3,6,8
Copal	223,293	214,309	1.04	1,3,5,6,7
Cumala blanca	1,425,226	227,293	6.27	1,2,3,5,6,7,8
Huayruro[1]	248,226	214,309	1.16	1,3,5,6,7
Hualaja	34,681	92,302	.38	1,2,6
Huimba	320,195	212,809	1.50	1,3,5,6
Ishpingo	1,686	6,000	.28	2
Lagarto caspi	11,564	56,000	0.21	2,6
Lupuna	578,773	212,809	2.72	1,3,5,6
Machin sapote	2,916	26,507	.11	3
Marupa	108,157	112,809	.96	1,3,6
Panguana	6,592	86,302	.08	1,6
Sapote	615,642	186,302	3.30	1,5,6
Shiringa	426,070	214,309	1.99	1,3,5,6,7
Ubos	178,473	112,809	1.58	1,3,6
Ucshaquiro blanco	139,564	112,809	1.24	1,3,6

* Inventory source numbers coincide with those on the list of inventories in Table 2
[1] *Ormosia coccinea* (Aubl.) Jacks

Table A.18 Area-weighted volume per unit area/species
Three-inventory Data Applicable to
Iquitos Region

Species	Growing stock m^3	Inventoried area - ha	Volume m^3/ha	Inventory source *
Caoba	25,876	89,227	.29	9
Carahuasca	1,323	900	1.47	10
Catahua	55,321	89,227	.62	9
Caucho masha	56,458	91,627	.62	7,9,10
Cedro	15,301	91,627	.17	7,9,10
Copaiba	5,354	89,227	.06	9
Copal	2,280	2,400	.95	7,10
Cumala blanca	778,070	91,627	8.49	7,9,10
Huayruro[1]	141,204	90,727	1.56	7,9
Huimba	780	1,500	.52	7
Ishpingo	78,520	89,227	.88	9
Lagarto caspi	68,046	90,127	.76	9,10
Lupuna	15,169	89,227	.17	9
Marupa	102,062	91,627	1.11	7,9,10
Moena amarilla	2,205	1,500	1.47	7
Moena negra	495	2,400	.21	7,10
Requia	885	1,500	.59	7
Sapote	144	900	.16	10
Shiringa	2,565	1,500	1.71	7
Ubos	16,061	89,227	.18	9

* Inventory source numbers coincide with those on the list of inventories in Table 2
[1] *Ormosia coccinea* (Aubl.) Jacks

Table A.19 Growing Stock and Years of Cut
Iquitos Region - 8,418,925 ha

Species	GS-1[1] MM m^3	Yrs.cut * 100 M m^3	Yrs.cut * 150 M m^3	GS-2[2] MM m^3	Yrs.cut 100 M m^3	Yrs.cut 150 M m^3	GS-3[3] MM m^3	Yrs.cut 100 M m^3	Yrs.cut 150 M m^3
Cachimbo	8.3	42	28	8.3	42	28			
Caoba	4.2	21	14	8.3	42	28	2.4	12	8
Carahuasca	9.8	49	33	9.8	49	33	12.4	62	41
Catahua	7.7	39	26	9.8	49	33	5.2	26	17
Caucho masha	5.6	28	19	1.4	7	5	5.2	26	17
Cedro	1.5	8	5	1.9	10	6	1.4	7	5
Copaiba	14.5	73	48	13.1	66	44	0.5	3	2
Copal	7.3	37	24	8.8	44	29	8.0	40	27
Cumala blanca	35.7	179	119	52.8	264	176	71.5	358	238
Huayruro (1)	8.8	44	29	9.8	49	33	13.1	66	44
Hualaja	4.0	20	13	3.2	16	11			
Huimba	12.8	64	43	12.6	63	42	4.4	22	15
Ishpingo	2.1	11	7	2.4	12	8	7.4	37	25
Lagarto caspi	0.6	3	2	1.8	9	6	6.4	32	21
Lupuna	18.5	93	62	22.9	115	76	1.4	7	5

Table A.19 Growing Stock and Years of Cut Iquitos Region -- continued

Species	GS-1[1] MM m^3	Yrs.cut * 100 M m^3	Yrs.cut * 150 M m^3	GS-2[2] MM m^3	Yrs.cut 100 M m^3	Yrs.cut 150 M m^3	GS-3[3] MM m^3	Yrs.cut 100 M m^3	Yrs.cut 150 M m^3
Machin sapote	5.1	26	17	0.9	5	3			
Marupa	4.3	22	14	8.1	41	27	9.3	47	31
Moena amarilla	26.7	134	89	26.7	134	89	12.4	62	41
Moena negra	6.7	34	22	6.7	34	22	1.8	9	6
Panguana	17.5	88	58	0.7	4	2			
Punga	2.4	12	8	2.4	12	8			
Requia	7.1	36	24	7.1	36	24	5.0	25	17
Sapote	33.5	168	112	27.8	139	93	1.3	7	4
Shiringa	12.5	63	42	16.8	84	56	14.4	72	48
Ubos	7.8	39	26	13.3	67	44	1.5	8	5
Ucshaquiro blanco	6.9	35	23	10.4	52	35			

* Achievement of 100 M m^3/150 M m^3 production requires approximately 200 M m^3/300 M m^3 of log input.
[1] GS-1 = Growing stock values calculated using volume/unit area/species from table A.16 times the area of the region. GS-1 = (Vol/unit area/species)*Area.
[2] GS-2 = Growing Stock values calculated using volume/unit area/species from table A.17 times the area of the region. GS-2 = (Vol/unit area/species)*Area.
[3] GS-3 = Growing Stock values calculated using volume/unit area/species from table A.18 times the area of the region. GS-3 = (Vol/unit area/species)*Area.
(1) *Ormosia coccinea* (Aubl.) Jacks

Table A.20 Growing Stock and Years of Cut
Pucallpa Region - 5,681,270 ha

Species	GS-1[1] MM m^3	Yrs.cut * 50 M m^3	Yrs.cut * 75 M m^3	GS-2[2] MM m^3	Yrs.cut 50 M m^3	Yrs.cut 75 M m^3
Cachimbo	5.6	56	37	5.6	56	37
Caoba	2.8	28	19	5.6	56	37
Carahuasca	6.6	66	44	6.6	66	44
Catahua	5.2	52	35	6.6	66	44
Caucho masha	3.7	37	25	1.0	10	7
Cedro	1.0	10	7	1.2	12	8
Copaiba	9.8	98	65	8.9	89	59
Copal	4.9	49	33	5.9	59	39
Cumala blanca	24.1	241	161	35.6	356	237
Huayruro (1)	5.9	59	39	6.6	66	
Hualaja	2.7	27	18	2.2	22	15
Huimba	8.6	86	57	8.5	85	57
Ishpingo	1.4	14	9	1.6	16	11
Lagarto caspi	0.4	4	3	1.2	12	8
Lupuna	12.5	125	83	15.5	155	103

Table A.20 Growing Stock and Years of Cut
Pucallpa Region -- continued

Species	GS-1[1] MM m^3	Yrs.cut * 50 M m^3	Yrs.cut * 75 M m^3	GS-2[2] MM m^3	Yrs.cut 50 M m^3	Yrs.cut 75 M m^3
Machin sapote	3.4	34	23	0.6	6	4
Marupa	2.9	29	19	5.5	55	37
Moena amarilla	18.0	180	120	18.0	180	120
Moena negra	4.5	45	30	4.5	45	30
Panguana	11.8	118	79	0.5	5	3
Punga	1.6	16	11	1.6	16	11
Requia	4.8	48	32	4.8	48	32
Sapote	22.6	226	151	18.7	187	125
Shiringa	8.4	84	56	11.3	113	75
Ubos	5.3	53	35	9.0	90	60
Ucshaquiro blanco	4.7	47	31	7.0	70	47

* Achievement of 50 M m^3/75 M m^3 production requires approximately 100 M m^3/150 M m^3 of log input.
[1] GS-1 = Growing Stock values calculated using volume/unit area/species from table A.16 times the area of the region. GS-1 = (Vol/unit area/species)*Area.
[2] GS-2 = Growing Stock values calculated using volume/unit area/species from table A.17 times the area of the region. GS-2 = (Vol/unit area/species)*Area.
(1) *Ormosia coccinea* (Aubl.) Jacks

11. APPENDIX 3

1. Advances in Technology and Techniques for Peeling

FAO (1976) reports that the outstanding technology attained in the plywood industry in recent times constitutes the development of high-speed automatic lathes equipped with dual hydraulic spindles together with high speed log charging and centering devices. This new technology has made possible the peeling of small diameter logs economically, and has contributed to the spectacular development of the southern pine plywood industry in the United States where the average log diameter is about 30 cm (12 in.). It has also been responsible for the continuing success of the Finnish plywood industry where the main resource, birch, decreased in average log diameter to 20-25 cm (8-10 in.). These logs can now be peeled down to a core diameter of 6-6.5 cm (2.4-2.6 in.).

Another recent development in veneer peeling is the division of the operation into two phases: prepeeling when the bolt is only rounded, and the actual peeling of veneer on the main lathe. Equipment for two-phased operation is reportedly under construction (FAO 1976). Most new developments in veneer peeling were oriented toward the improvement of design and performance of lathes and its devices. According to Lutz (1978) the heart of any lathe are the knife and pressure bar. It is on the pressure bar that most advances in technology have taken place.

Walser and McLauchlan (1977) and Lutz (1978) note the importance of the nosebar as one of the major components of any veneer lathe, and also its importance in veneer cutting. To improve veneer quality during rotary cutting, a nosebar is pressed against the bolt just ahead of the knife edge (Figure A.1). This nosebar pressure helps to control the roughness, depth of checks and thickness uniformity of the veneer.

Two types of nosebars are commonly used, the fixed nosebar and the roller nosebar (Figure A.2). Each of them (Walser and McLauchlan 1977), is best suited to a specific cutting condition. The fixed nosebar is used for peeling thin hardwood veneers

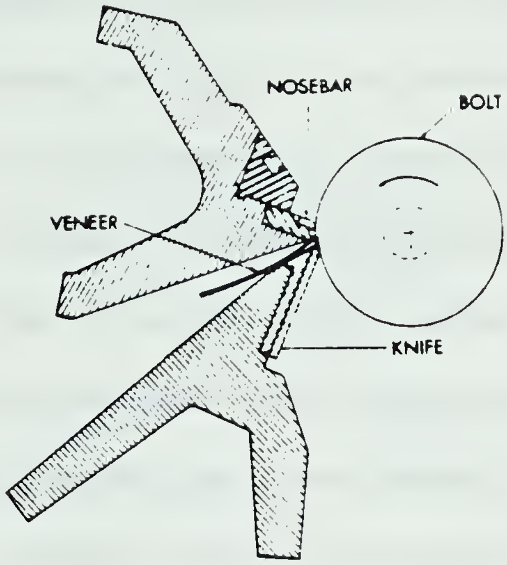

Figure A.1 Cross-section veneer lathe.

Reproduced from Walser and McLauchlan (1977) with the permission of the authors.

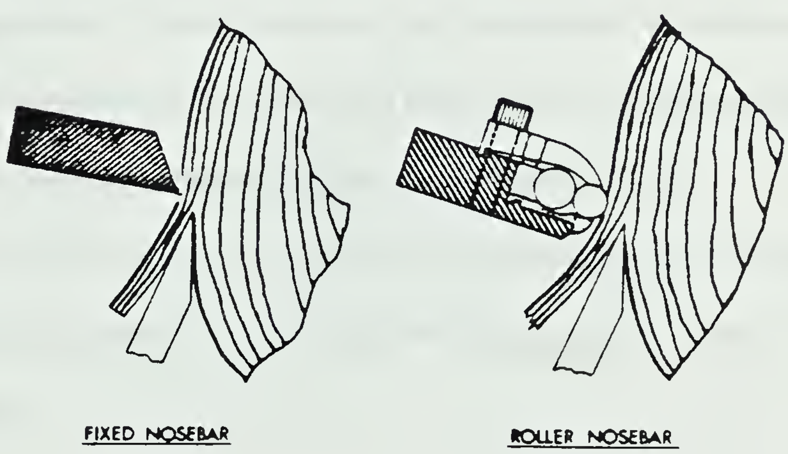

Figure A.2 Types of nosebars.

Reproduced from Walser and McLauchlan (1977) with the permission of the authors.

while the roller nosebar is for cutting thicker softwood veneers. The advantages and disadvantages of the two nosebars are shown in Figures A.3 and A.4.

Considering the disadvantages of the fixed and roller nosebars, the Western Forest Products Laboratory (Forintek Canada Corp.) designed a new nosebar called the contoured heated nosebar whose basic concepts are displayed in Figure A.5. Laboratory tests have shown promising results in achieving better veneer quality, and therefore trials were conducted on industrial veneer lathes using a design shown in Figure A.6. Preliminary results indicated that veneer quality improvement is comparable to that observed in the laboratory. Youngquist (1981) and Fronczak and Loehnertz (1982) report another recent technology for veneer peeling developed at the Forest Product Laboratory (Madison). It is a powered back-up roll device designed to provide auxiliary torque to a veneer bolt during peeling. This reduces the probability of spin-out occurring and allows a reduction in the final core size when used in conjunction with smaller chucks. This device can either be added to existing veneer lathes or incorporated into new lathe systems (Figure A.7).

The major problems associated with veneer peeling which cause reduction in veneer yield have been spin-out, large core size, and unpeelable logs due to their bad centers. Industrial performance of the powered back-up roll has proved satisfactory in reducing spin-out and increasing veneer recovery (Loehnertz 1982).

The net result of this new technology is the increased yield from veneer logs by cutting to smaller core size and the use of logs with relatively soft centers, thus expanding the timber resource base.

2. Advances in Technology and Techniques for Drying

Feihl *et al.* (1977) and Lutz (1978) indicate the importance of drying veneer to an adequate moisture content level, and the variation of it according to the end use of the veneer. Veneers used in products such as bushel baskets and fruit containers require only

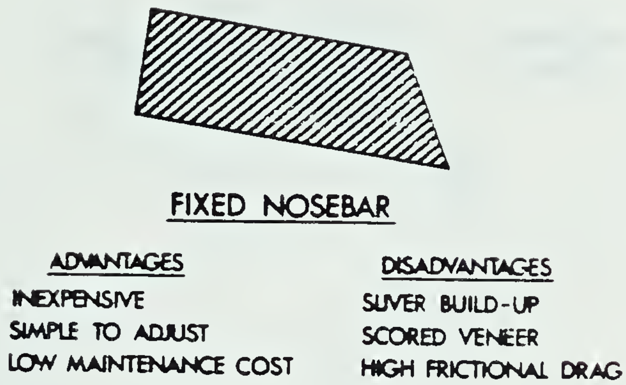

Figure A.3 Advantages and disadvantages of fixed nosebar.

Reproduced from Walser and McLauchlan (1977) with the permission of the authors.

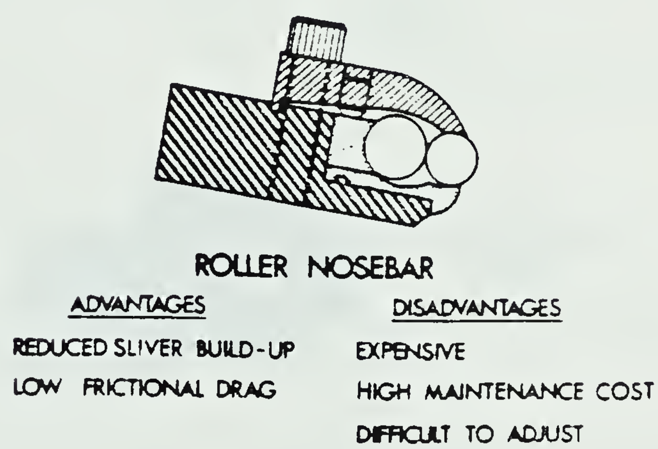

Figure A.4 Advantages and disadvantages of roller nosebar.

Reproduced from Walser and McLauchlan (1977) with the permission of the authors.

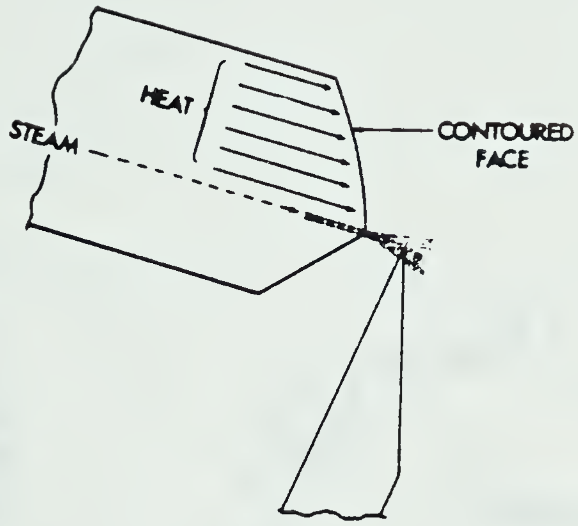

Figure A.5 Basic concept of the contoured heated nosebar.

Reproduced from Walser and McLauchlan (1977) with the permission of the authors.

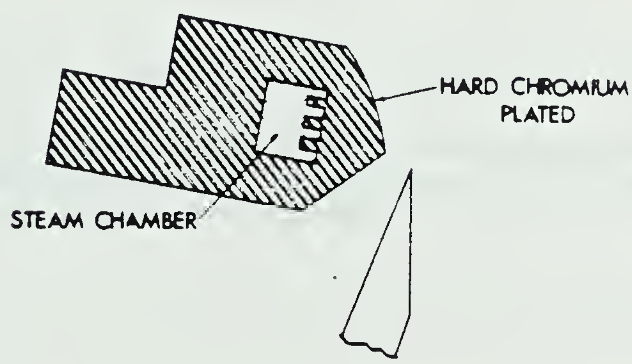

Figure A.6 Mill contoured heated nosebar.

Reproduced from Walser and McLauchlan (1977) with the permission of the authors.

Figure A.7 Concept of the powered back-up roll.

Reproduced from Youngquist (1981) with the permission of Forest Products Laboratory, Forest Service, U.S. Department of Agriculture, Madison, WI 53705.

a final drying moisture content of 20 percent, while for construction plywood the veneer must have a maximum moisture content of 5 percent to allow proper curing of the phenolic resins used. Veneers for interior use plywoods, mostly hardwoods, that are to be glued with non-waterproof urea glues need only a moisture content range of 6 to 8 percent.

Thus, drying of veneer to the required moisture content without degradation and with efficiency continues to be the greatest production bottleneck in veneer and plywood plants (FAO 1976). It is predicted that in the future greater changes in veneer drying techniques will take place than in any other area of plywood manufacture.

Dryers are categorized by air flow pattern and/or heating method (Feihl *et al.* 1977). Two major types of air flow patterns are used in veneer drying; they are:

1. the longitudinal flow type, and
2. the cross circulation flow type.

Both types are divided into zones, but the distinguishing feature between them is that a cross circulation dryer can have as many as ten zones (separations of air flow patterns or temperature control areas) compared with a longitudinal dryer which usually has a maximum of three zones. Both types also have flow dryer fans to circulate the air during the drying process.

FAO (1976); Feihl *et al.* (1977); Lutz (1978) and Roubicek (1980) report that the further refinement of the cross circulation dryer constitutes the jet dryer. Compared to the other two types of dryers, the jet dryer provides more capacity with an equivalent physical size by using high velocity, high temperature air jet nozzles. This new technology improved dryer efficiency and decreased the cost of the dryers as the required deck sections were cut in half.

Other developments in the technology of drying have also taken place in hardwood plywood manufacture as reported by FAO (1976). It proved useful in most of the hardwood mills to have both a continuous and a roller dryer because a range of veneer

thicknesses and sizes had to be dried. Face veneers are dried continuously while core stock and round-ups are put through a roller dryer. This yields flexibility and economy in the drying process.

With respect to heating methods, Feihl *et al.* (1977) reports that steam and direct-fired gas are the most commonly used methods. Both techniques can be used in the same type of dryer. Direct-fired dryers are usually fueled by natural or liquified petroleum gas.

Another improvement of dryer productivity (Roubicek 1980) constitutes the computerized dryer speed control ruled by moisture detectors on the dryer outfeed end. Generally, a dryer operator manually speeds up or slows down the system when there is too large a variance from the optimal 10 percent of veneer to be redried, as marked by the moisture meter. However, the computerized system detects the impulses of the moisture meter and adjusts the speed of the dryer automatically.

3. Advances in Technology and Techniques for Gluing

Conventional plywood manufacture in many parts of the world have used double roll spreaders for glue application to veneers (FAO 1976). Over the years, roll spreaders have evolved considerably. New refinements are the soft and hard rubber rolls with special grooving designed for specific adhesives and special controls for roll pressure resulting in higher quality of glue application. The newest innovation is a roll spreader with an extra pair of sponge rubber rolls. This allows lower variation in glue spread than hard rubber rolls when applied to veneer with thickness variations.

The alternative to roller spreading was curtain coating (FAO 1976). However, glue spray application systems are a definite improvement over roll spreaders and curtain coating systems (Bauer 1980). This system provides lay-up flexibility, quality, glue savings, improves wood utilization and productivity.